(1)

SSC-340

ICE FORCES AND SHIP RESPONSE TO ICE

CONSOLIDATION REPORT

SHIP STRUCTURE COMMITTEE

1990

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December 3, 1990

SSC-340
SR-1308

ICE LOADS AND SHIP RESPONSE TO ICE
CONSOLIDATION REPORT

This report is the third in a series of six that address ice loads, ice forces, and ship response to ice. The data for these reports were obtained during deployments of the U.S. Coast Guard Icebreaker POLAR SEA. This report contains an extreme value analysis of the pressure and force data collected during four deployments. These statistics should be useful in assessing criteria for the design of ice breaking hulls. The other ice reports are published as SSC-329, SSC-339, SSC-341, SSC-342 and SSC-343.

J. D. SIPES
Rear Admiral, U.S. Coast Guard
Chairman, Ship Structure Committee

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16. Abstract

This report presents the results and final analysis of the local ice load measurement conducted on the four deployments aboard the USCGC POLAR SEA between 1982-84. Data were collected in first year and multiyear level ice in McMurdo Sound, Antarctica. The first and second deployment results from trips to the Alaskan Arctic as well as the instrumentation and data analysis techniques were presented in "Ice Loads and Ship Response to Ice" (SSC-329) (reference 1). The third deployment results from the Antarctic were presented in a report to the Maritime Administration (Reference 2). Results of the fourth data collection program from the Beaufort Sea in the summer of 1984 are presented in "Ice Loads and Ship response to Ice - A Second Season" (SSC-339) (Reference 4). This report summarizes the previous data collection programs and provides the final data analysis of all data as a whole.

A statistical analysis of extreme pressures and forces was performed for the data collected on all four deployments and is presented in this report. Pressures over one subpanel, four subpanels, and forces on frames, stringers (as if the ship were longitudinally framed), and the total load on the panel were fitted to 3 parameter extreme value distributions. The results of the extreme value statistics performed were then used to suggest ice load criteria in support of icebreaking ship design and hull design regulations for icebreaking ships.

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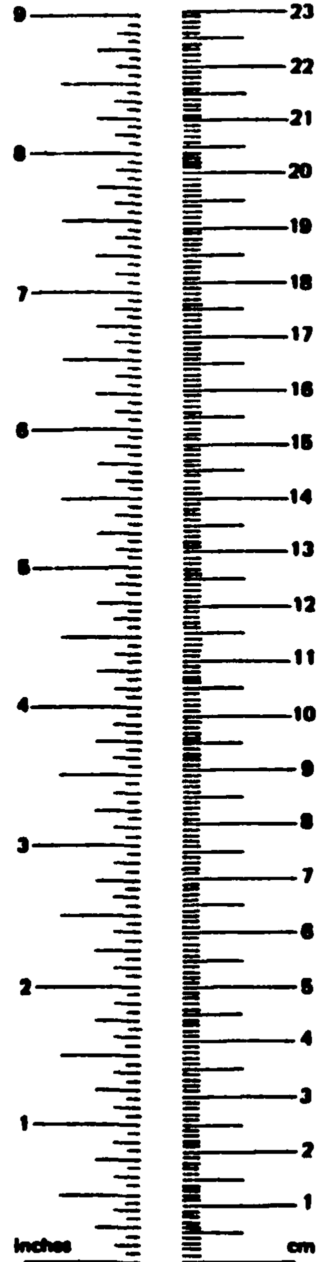
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

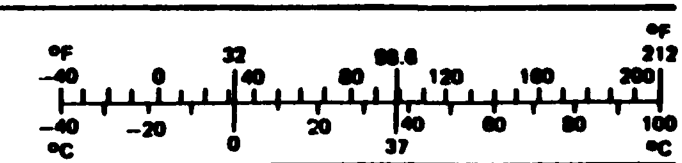
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286. Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This report presents the results and final analysis of the local ice load measurement conducted on the four deployments aboard the USCGC POLAR SEA between 1982-84. Data were collected in first year and multiyear level ice in McMurdo Sound, Antarctica. The first and second deployment results from trips to the Alaskan Arctic as well as the instrumentation and data analysis techniques were presented in "Ice Loads and Ship Response to Ice" (SSC-329) (reference 1). The third deployment results from the Antarctic were presented in a report to the Maritime Administration (Reference 2). Results of the fourth data collection program from the Beaufort Sea in the summer of 1984 are presented in "Ice Loads and Ship response to Ice - A Second Season" (SSC-339) (Reference 4). This report summarizes the previous data collection programs and provides the final data analysis of all data as a whole.

A statistical analysis of extreme pressures and forces was performed for the data collected on all four deployments and is presented in this report. Pressures over one subpanel, four subpanels, and forces on frames, stringers (as if the ship were longitudinally framed), and the total load on the panel were fitted to 3 parameter extreme value distributions. The results of the extreme value statistics performed were then used to suggest ice load criteria in support of icebreaking ship design and hull design regulations for icebreaking ships.

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Consolidation Report

1. INTRODUCTION

In 1982, USCGC POLAR SEA was instrumented with an array of strain gages on the port bow for the purpose of measuring ice impact pressures. Two trips to the Alaskan Arctic were made in October 1982 and March-April 1983 during which time about 1400 impact events were collected. The research was carried out on behalf of the Interagency Ship Structure Committee, the U.S. Maritime Administration, and Transport Canada (Transportation Development Centre). Work was performed in conjunction with environmental data collection programs sponsored by the Alaskan Oil and Gas Association and the U.S. Maritime Administration.

Ten cant frames (CF 35 to CF 44) were instrumented at 8 vertical locations by strain gaging the webs of the frames in compression perpendicular to the shell plating (Figure 1). A total of sixty active channels of strain gages allowed contact pressures over an area of up to 98 ft^2 (9.1 m^2) to be measured. An individual strain gage channel was related to an area of 1.63 ft^2 (.15 m^2) for which a uniform pressure was computed for a measured strain. A complete description of the data acquisition system and the data reduction procedures as well as the results of the two deployments can be found in Reference [1]*.

The POLAR SEA's trip to the Antarctic in January 1984 offered a third opportunity to collect ice impact data in thick level ice in conjunction with resistance tests sponsored by the Maritime Administration (MARAD), Naval Engineering Division of the U.S. Coast Guard and Canadian Transportation Development Centre (TDC). An additional 310 ice impact events were collected by this effort and are reported under contracts to MARAD [2] and TDC [3].

A fourth data collection program was conducted in October and November of 1984, termed the 1984 Summer Deployment, to gather additional data in summer multiyear ice conditions where the highest loads could be expected. This deployment recorded 337 impact events which are presented and analyzed in SSC-339 [4]. This report summarizes data from all four deployments and presents further analysis of the complete data set.

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* Numbers in brackets refer to references listed in Section 8.

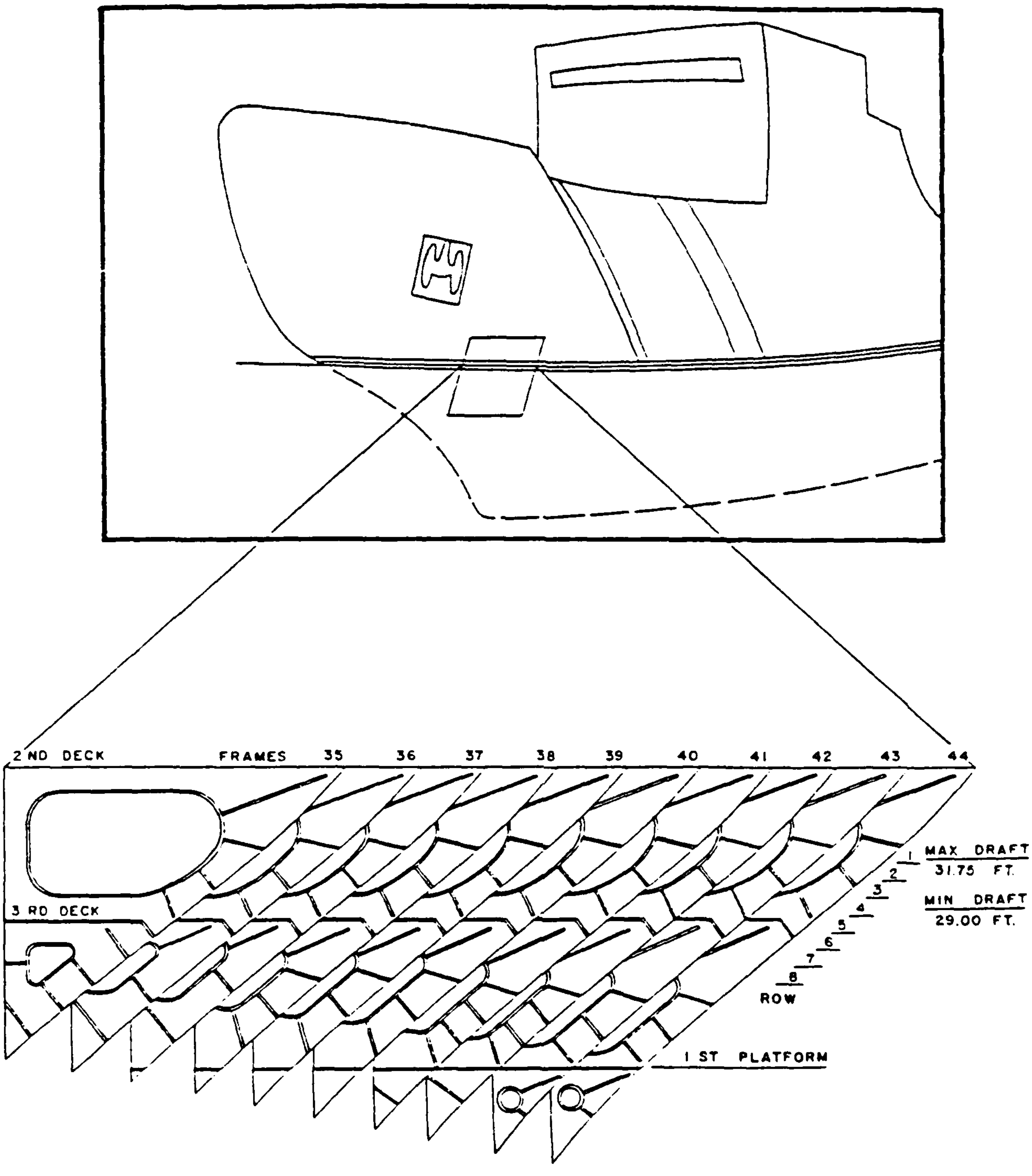


Figure 1

STRAIN GAGE LOCATIONS ON POLAR SEA

2. SUMMARY OF THE MEASUREMENT PROGRAMS, COLLECTED DATA AND ICE CONDITIONS

The local ice impact loads data collection program has made use of four deployments of POLAR SEA between the fall of 1982 and the fall of 1984 to acquire data in different geographical areas. Seven data sets are identified by geographical area and date of data collection. The data sets, representing 2039 individual impact events, are summarized in Table 1. A listing summarizing the extremes of each event for each data set can be found in Appendix A, sorted by the highest average single sub-panel pressure. Actual routes of the ship or operating areas where the data were collected are shown on the maps in Figures 2 and 3.

For two of the data sets involving ice conditions that included both first-year and multi-year ice, it was possible to identify subsets of known multi-year impacts. Sixty-seven known multi-year known multi-year events were identified in the North Chukchi Winter 83 data which included the dedicated rams of multi-year ridges described in Reference 1. An additional 32 known multi-year events were identified in the Summer Beaufort 84 data set. The multi-year subsets are summarized at the bottom of Table 1. It should be noted that many more multi-year events occurred and were recorded in the South Chukchi Winter 83, North Chukchi Winter 83 and Beaufort Summer 84 data sets, however specific multi-year events could not be identified. The Beaufort Summer 82 data were collected at a time when only multi-year ice, with the exception of light refreeze, existed in the area.

Table 2 presents combined data sets that were grouped according to ice conditions first and, secondly, according to geograpnic area. The data sets were grouped to provide the largest collection of data of similar conditions for the extreme value analysis of Section 4. In this type of analysis, larger data sets provide improved extrapolation to the longer return periods.

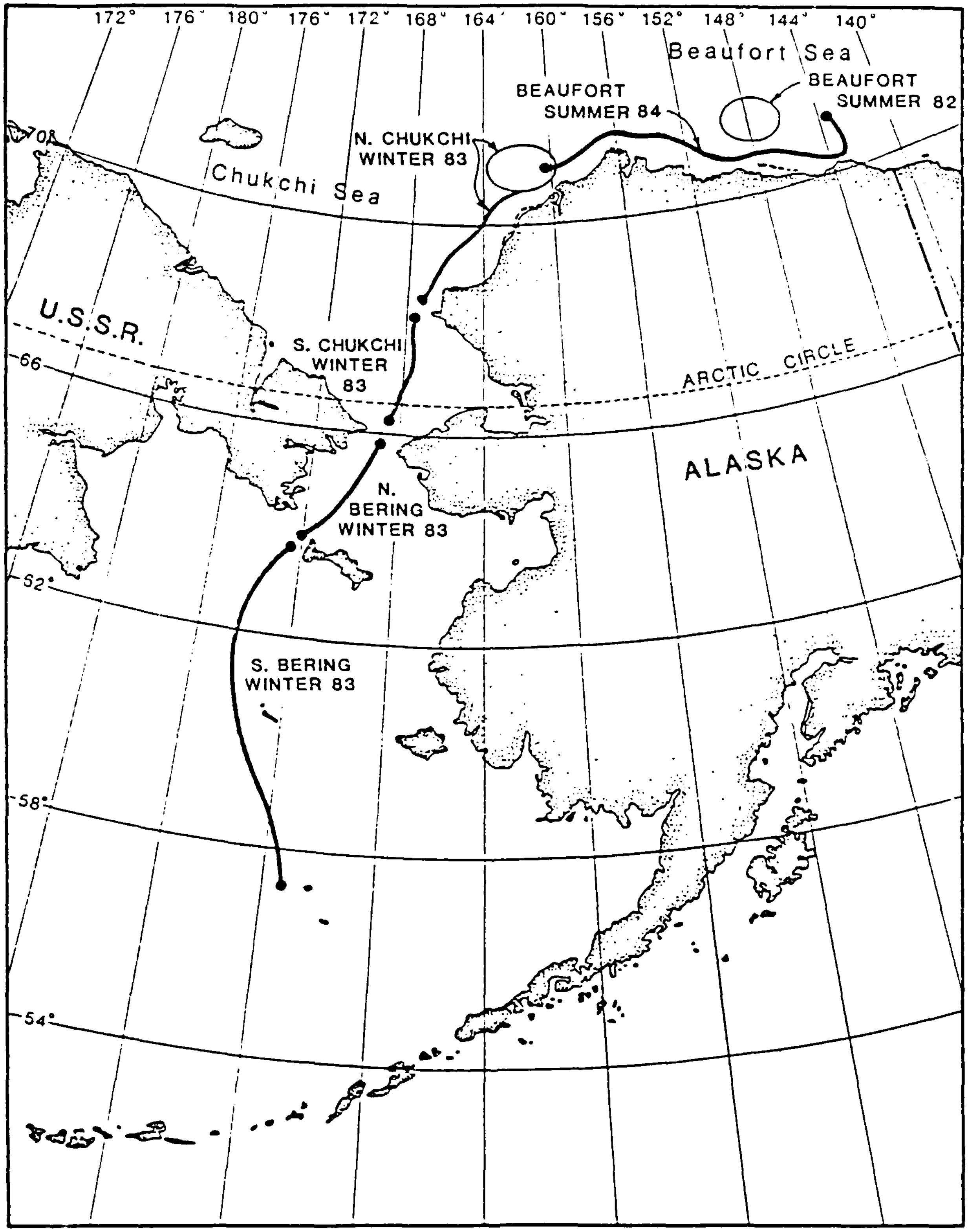


Figure 2

LOCATIONS OF DATA COLLECTION EFFORTS IN THE ALASKAN ARCTIC

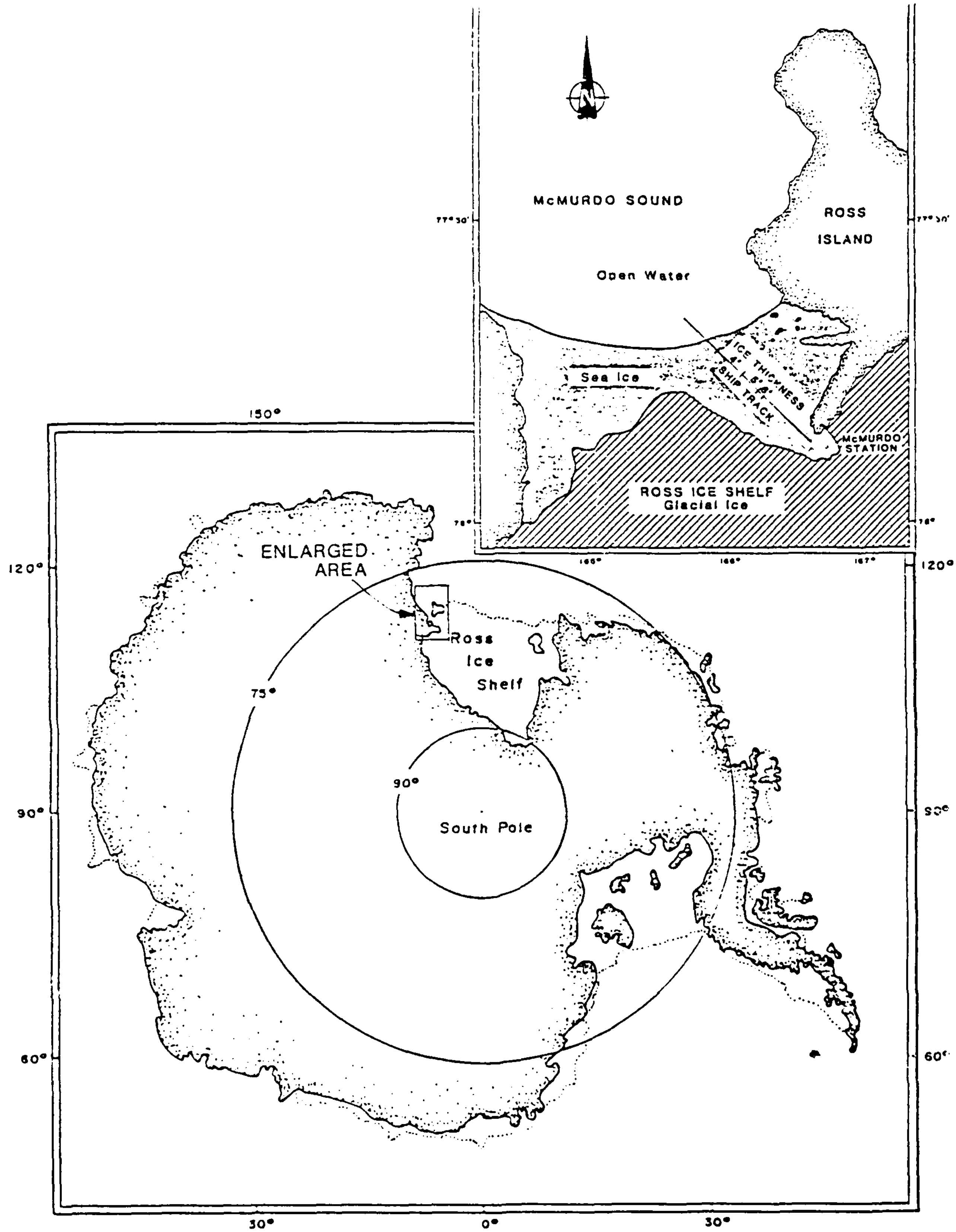


Figure 3

LOCATION OF ANTARCTIC ICE LOADS DATA COLLECTION

TABLE 1

SUMMARY OF DEPLOYMENTS, DATA SETS AND ICE CONDITIONS

TITLE & DATE	LOCATION	ICE TYPE	NO OF EVENTS
Beaufort Summer 82 Sep 28 - Oct 16	100-150 nm north of Prudhoe Bay in the Alaskan Beaufort Sea	MY	167
S Bering Winter 83 Mar 24 - Mar 26	Transit from St.Paul Is. to the west end of St.Lawrence Is. in the Bering Sea	FY	173
N Bering Winter 83 Mar 27 - Mar 28	Transit from St. Lawrence Is. to the Bering Strait in the Bering Sea	FY	241
S Chukchi Winter 83 Mar 29 -Apr 2 Apr 28 - May 2	Transit from the Bering Strait to Point Hope in the Chukchi Sea and return	FY,MY	299
N Chukchi Winter 83 Apr 3 - Apr 27	Round trip transit Point Hope to Wainwright in the Chukchi Sea, operation off Wainwright	FY,MY	513
Antarctic Summer 84 Jan 9 - Jan 13	McMurdo Sound, break-in to McMurdo Base	FY	309
Beaufort Summer 84 Nov 18 - Dec 1	Operation between Barter Is. and Barrow in the Beaufort Sea, transit through the Chukchi Sea to the Bering Strait	FY,MY	337

SUBSETS OF KNOWN MULTI-YEAR EVENTS

N Chukchi Winter 83 MY Apr 3 - Apr 27	North Chukchi Sea off Wainwright	MY	67
Beaufort Summer 84 MY Nov 12 - Dec 1	Beaufort and Chukchi Seas	MY	32

TABLE 2

SUMMARY OF COMBINED DATA SETS

TITLE	COMBINED FROM	ICE TYPE	NO OF EVENTS
Known Multi-Year	Beaufort Summer 82 N Chukchi Winter 83 MY Beaufort Summer 84 MY	MY	266
Heavy Mixed FY & MY	Beaufort Summer 82 S Chukchi Sea 83 N Chukchi Sea 83 Beaufort Summer 84	FY,MY	1017
Known First-Year	S Bering Winter 83 N Bering Winter 83 Antarctic Summer 84	FY	723
Summer Beaufort Sea	Beaufort Summer 82 Beaufort Summer 84	mostly MY	504
Winter Chukchi Sea	S Chukchi Winter 83 N Chukchi Winter 83	FY,MY	398
Winter Bering Sea	S Bering Winter 83 N Bering Winter 83	FY	812

3. ANALYSIS OF PRESSURE VERSUS CONTACT AREA RELATIONSHIPS

The intent of this section is to investigate specific relationships that may exist among the data collected. Section 3.1 examines an actual event to illustrate the nature of the measured pressures. Section 3.2 looks at average pressure over the contact area. Three of the data sets (North Chukchi Winter 83, South Bering Winter 83 and Antarctic Summer 84) are used to illustrate three major operating scenarios; high Arctic with old ice, first-year ice near the ice edge and first-year thick level ice. Section 3.3 shows the influence (or lack there of) of impact force on velocity.

3.1 Pressure Imprint Descriptions

Ice pressure is calculated at each time step within an event by multiplying the sixty measured strains by a 60 x 60 matrix to produce the sixty average ice pressures over the sub-panel areas. Results from each event are saved in the form of an impact pressure time-history. Figure 4 shows these calculated pressures for five sequential time-steps for an event taken from the North Chukchi Winter 83 data set. Sampling occurred 32 times per second so the time-step shown is .031 seconds. The values printed are in psi (145 psi = 1 MPa) and are arranged in the same manner as the sub-panel areas on the hull.

This event took place during April, 1983 in the North Chukchi Sea, resulting in a peak pressure of 1141 psi (7.9 MPa). To illustrate the impact, all values above 100 psi (0.69 MPa) were highlighted. The sub-panels are approximately square so this event has a length to height ratio of about 4. Part of the event may be below the panel which would reduce this ratio.

A few negative values can be seen both near the imprint and on the "quiet" portions of the panel. Two factors account for the negative values. One is a shift in the zeroes of all channels due to thermal effects. New zeroes could only be taken when there was no load on the panel and often this was not possible. Negative zero shifts result in measured values below the true value. Near the impact, negative values could also result from an assumption in the data reduction algorithm. The algorithm assumes that the impact pressure is uniform over the sub-panel area. If the actual impact is concentrated over a smaller area than the sub-panel, the uniform pressure for that sub-panel will be over-predicted and the adjacent sub-panels will be under-predicted (negative if there was no actual load on them). The two effects cancel and are therefore not expected to, cause any significant errors (i.e. less than 10 percent).

Software was developed during the 1984 Antartic deployment to correct the thermal drift problem. This involves viewing and zeroing each strain gage time-history prior to data reduction. All data collected after 1983 has employed this method as part of the data reduction process. Additionally, revision of the data reduction matrix to include the effects of non-uniform sub-panel loading has been studied. While reduction of all the data sets a second time with an improved matrix would improve the accuracy of the predicted pressures, the improvement would not affect the final results significantly and would not warrant the effort required.

PRESSURES AT EACH TIME STEP DURING THE EVENT

											TIME (sec)
TIME STEP	53										
FRAME	44	43	42	41	40	39	38	37	36	35	
ROW											
3	-59	-39	-36	-36	-36	-30	-34	-30	-21	-26	
4	-12	-34	-22	-50	-35	-17	+9	-6	-12	-1	
5	-8	+8	-3	-1	+13	-24	+7	+9	+5	-33	
6	-5	+37	+61	+54	+52	+81	+21	+101	+81	+108	-.093
7	+8	+39	-3	+4	+433	+550	+43	+19	+69	+24	
8	-1	+331	+614	+767	+338	+62	+37	-21	-3	-26	
TIME STEP	54										
FRAME	44	43	42	41	40	39	38	37	36	35	
ROW											
3	-59	-44	-41	-36	-35	-28	-32	-33	-20	-24	
4	-20	-41	-22	-56	-27	-10	+5	-7	-10	-3	
5	-10	+8	-8	+0	+13	-26	+7	+6	-15	-28	-.062
6	-5	+51	+68	+46	+58	+77	+29	+116	+85	+77	
7	+25	+7	-40	+22	+449	+410	+16	+32	+109	+29	
8	+52	+505	+874	+888	+213	+36	+17	-16	-19	-24	
TIME STEP	55										
FRAME	44	43	42	41	40	39	38	37	36	35	
ROW											
3	-49	-49	-45	-33	-35	-33	-35	-31	-18	-21	
4	-30	-53	-25	-59	-21	-2	+2	-6	-11	-2	
5	-13	+11	-16	+4	+14	-26	+6	-6	-23	-18	-.031
6	-3	+68	+71	+35	+52	+73	+54	+114	+71	+44	
7	+32	-41	-50	+90	+474	+240	+18	+58	+150	+30	
8	+154	+676	+991	+888	+75	+35	+12	-21	-36	-19	
TIME STEP	56										
FRAME	44	43	42	41	40	39	38	37	36	35	
ROW											
3	-44	-56	-44	-33	-34	-30	-31	-33	-15	-22	
4	-42	-68	-21	-55	-12	+0	-4	-6	-10	-2	0
5	-13	+11	-26	+9	+16	-21	-1	-12	-21	-13	
6	+4	+91	+71	+25	+25	+62	+88	+92	+48	+28	
7	+27	-88	-50	+184	+409	+115	+24	+99	+184	+24	
8	+306	+790	+1141	+766	-32	+24	+15	-30	-53	-10	
TIME STEP	57										
FRAME	44	43	42	41	40	39	38	37	36	35	
ROW											
3	-41	-60	-41	-31	-31	-31	-31	-27	-15	-22	
4	-48	-76	-20	-49	-4	-3	-8	-4	-10	-2	
5	-17	+8	-31	+12	+14	-18	-6	-19	-12	-12	+.031
6	+10	+98	+68	+18	+8	+55	+111	+66	+26	+26	
7	+17	-114	+1	+238	+242	+61	+31	+161	+204	+20	
8	+431	+823	+1118	+581	-51	+11	+31	-48	-58	+1	

EVENT RECORDED IN THE NORTH CHUKCHI SEA ON APRIL 24, 1983 AT 16:11:59

Note: Values above 100 Psi (.69MPa) are highlighted

Figure 4

EXAMPLE OF AN ICE PRESSURE IMPRINT

3.2 Average Pressure versus Contact Area

There are many ways to plot pressure versus area. In this section only the average pressure over the total contact area will be considered. This should not be confused with the average pressure over some smaller area within the contact area. In this section, data points associated with a single sub-panel area imply that the total contact area was only one sub-panel area for that event and so forth for larger areas. Higher average pressures over a portion of the contact area are not plotted. It is important not to confuse a plot such as Figure 5 with one such as Figure 10 that plots highest average pressures within the contact zone.

Looking at average pressure and contact area helps to understand the mechanics of the impact event. To make use of this data for design, it is useful to know the contact area associated with a given force (which implies a certain average pressure over the contact area). In this section, the pressure versus height (line loads on transverse frames) and pressure versus length (line loads on longitudinal framing) will also be presented.

Figure 5 shows the average pressure versus contact area for 3 of the data sets. Figure 5a is from the North Chukchi Sea 83 data and represents the high Arctic with considerable multi-year ice. Clearly the large imprints have lower average pressures. At 86 ft^2 (8 m^2), the pressure tends to cluster around 60 psi (0.4 MPa). Figures 5b and 5c show similar data for the South Bering Sea 83 and Summer Antarctic 84 data. The relatively light first-year ice conditions of the South Bering Sea produced low average pressures over the contact area. The Antarctic data taken in thick first-year ice fell between the other two data sets.

The same data can be viewed as a plot of force versus contact area shown in Figure 6. The highest force in the North Chukchi Winter 83 data set (Figure 6a) occurred at only 43 ft^2 (4 m^2). One would expect the highest forces to be associated with the largest contact areas, in general, as the other data sets show (Figure 6b and 6c). Possibly there were insufficient high energy impacts in hard ice to generate both large forces and contact areas at the same time. The randomness of the ice properties could also be responsible. Figures 6b and 6c show a much clearer trend of increasing force with contact area, however.

Figures 7 and 8 show the average pressure as a function of vertical and horizontal extent. These values are useful in predicting the loads on local framing members. Later sections will further examine the implications to design.

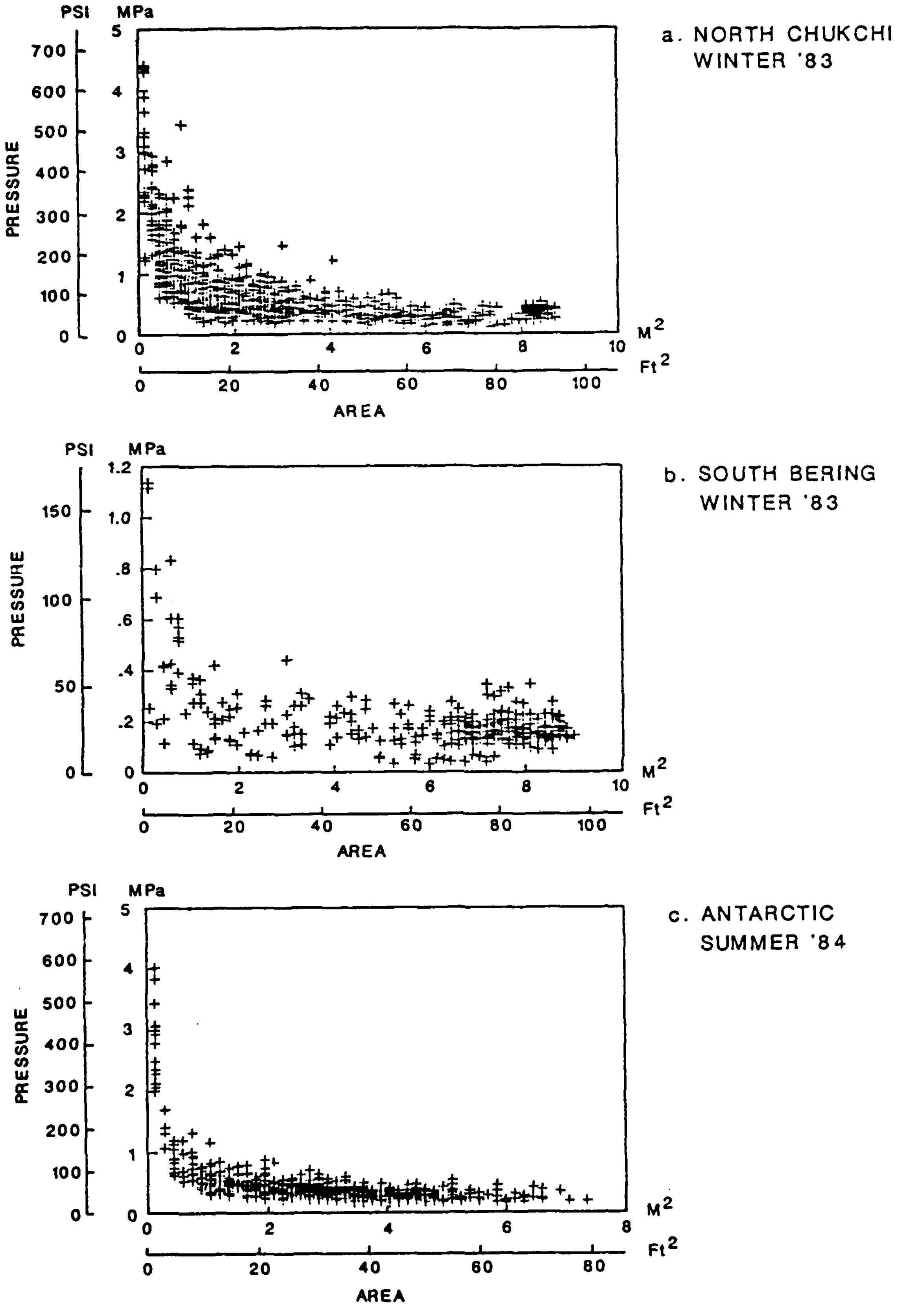


Figure 5

AVERAGE PRESSURE VERSUS TOTAL CONTACT AREA

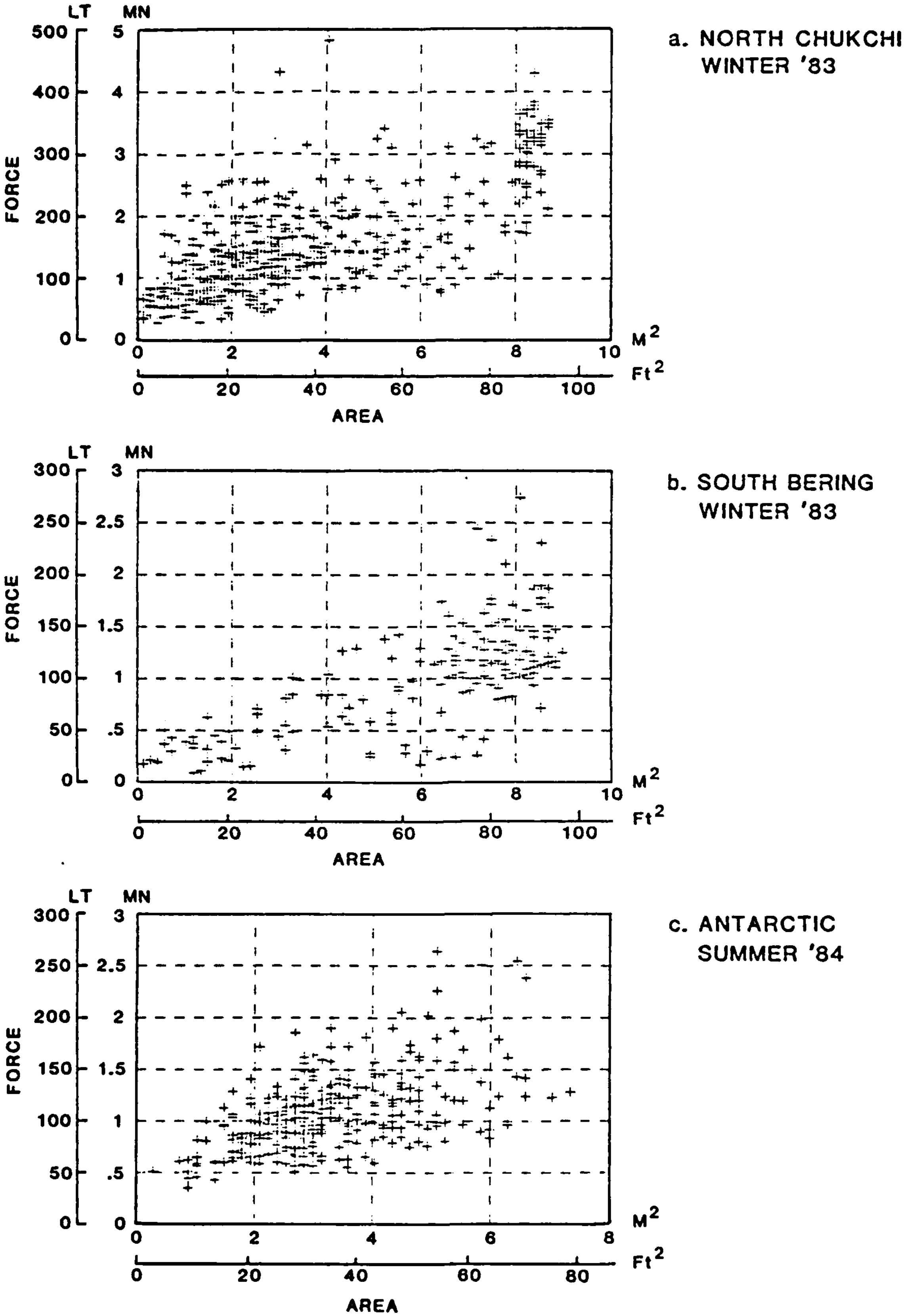


Figure 6

TOTAL FORCE VERSUS TOTAL CONTACT AREA

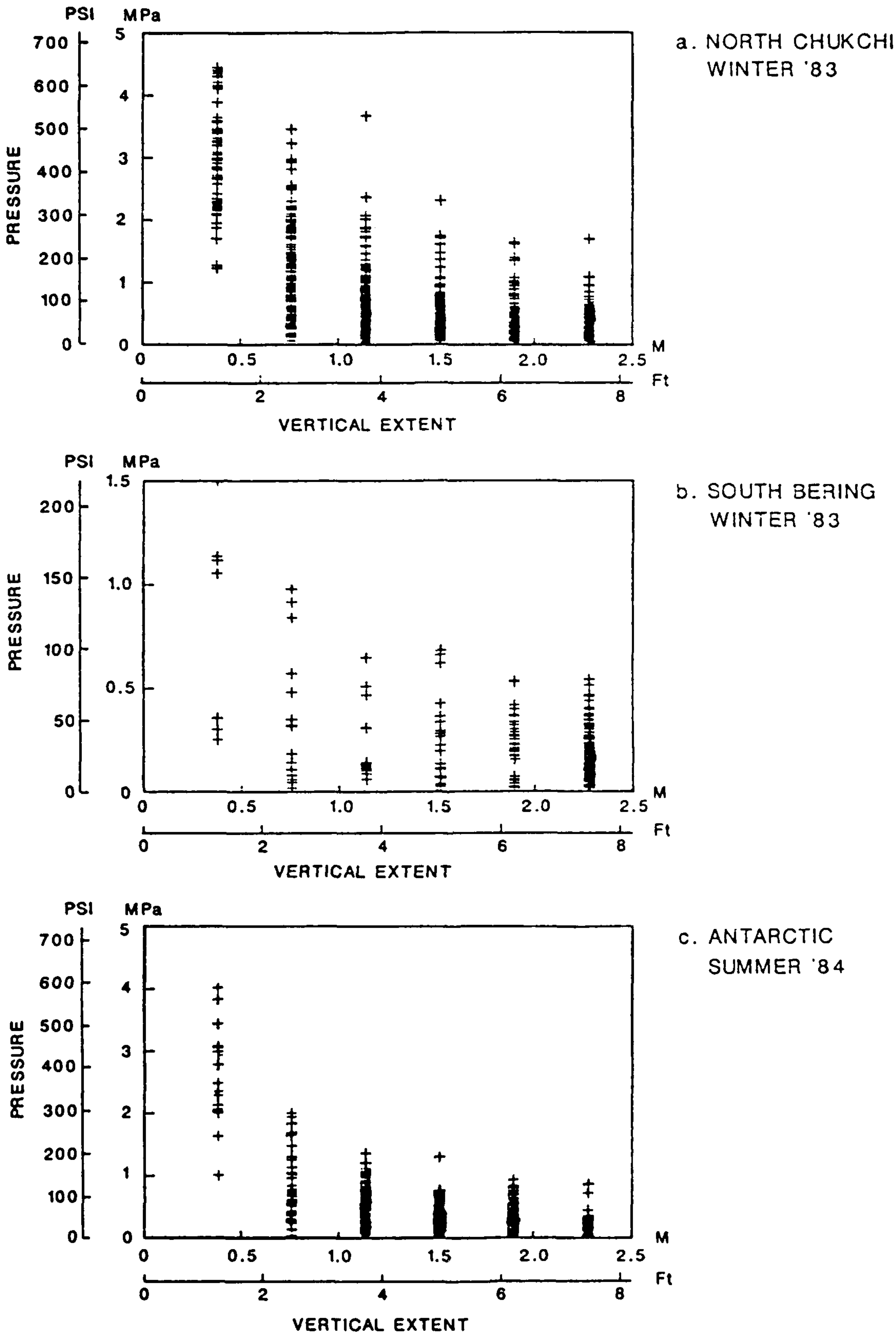


Figure 7

AVERAGE PRESSURE VERSUS HEIGHT

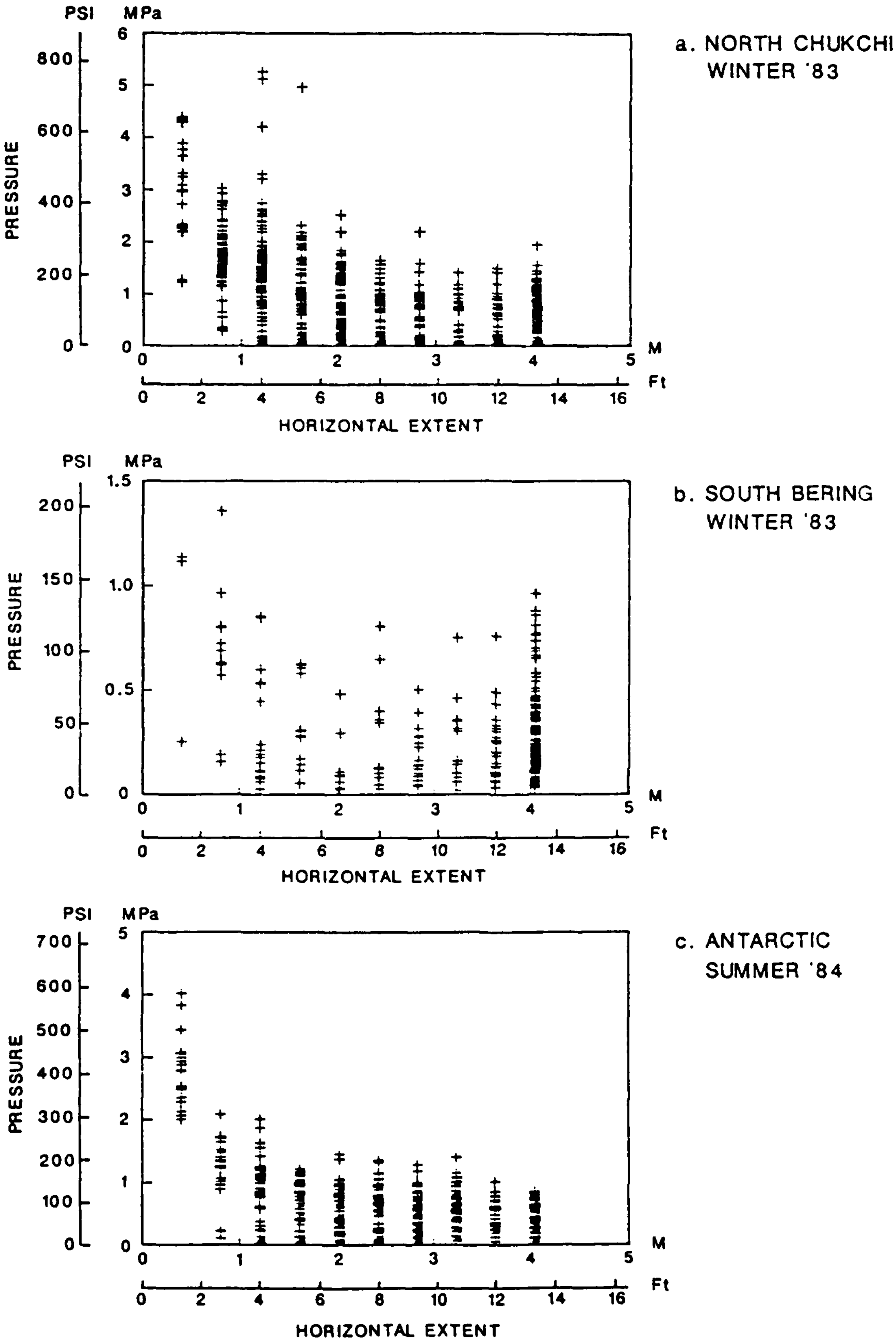


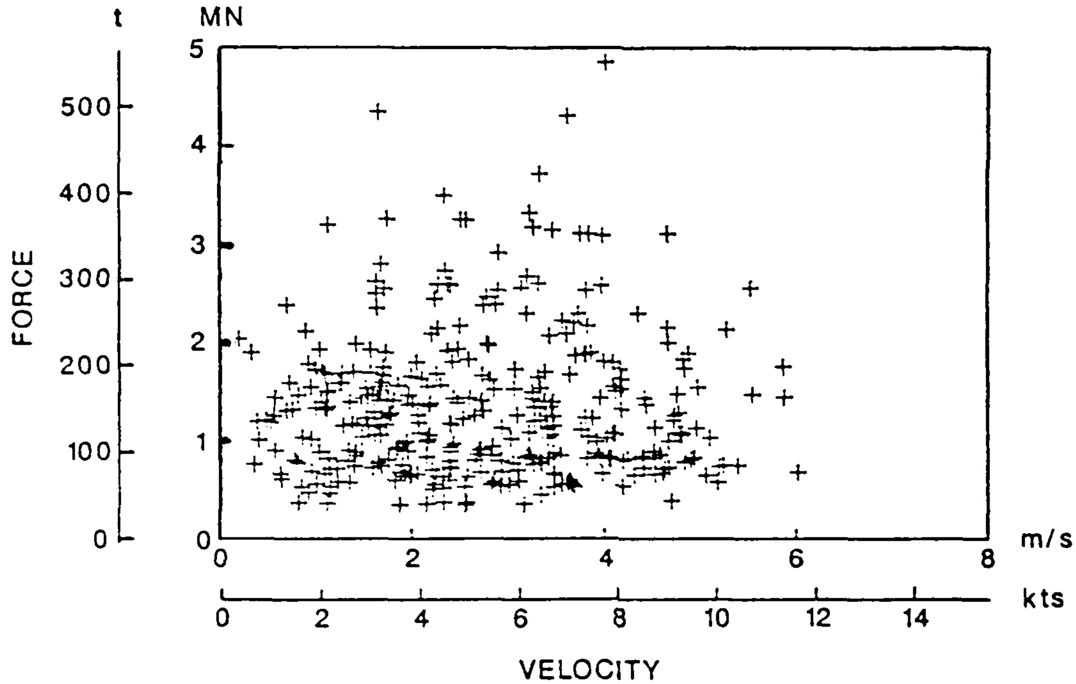
Figure 8

AVERAGE PRESSURE VERSUS LENGTH

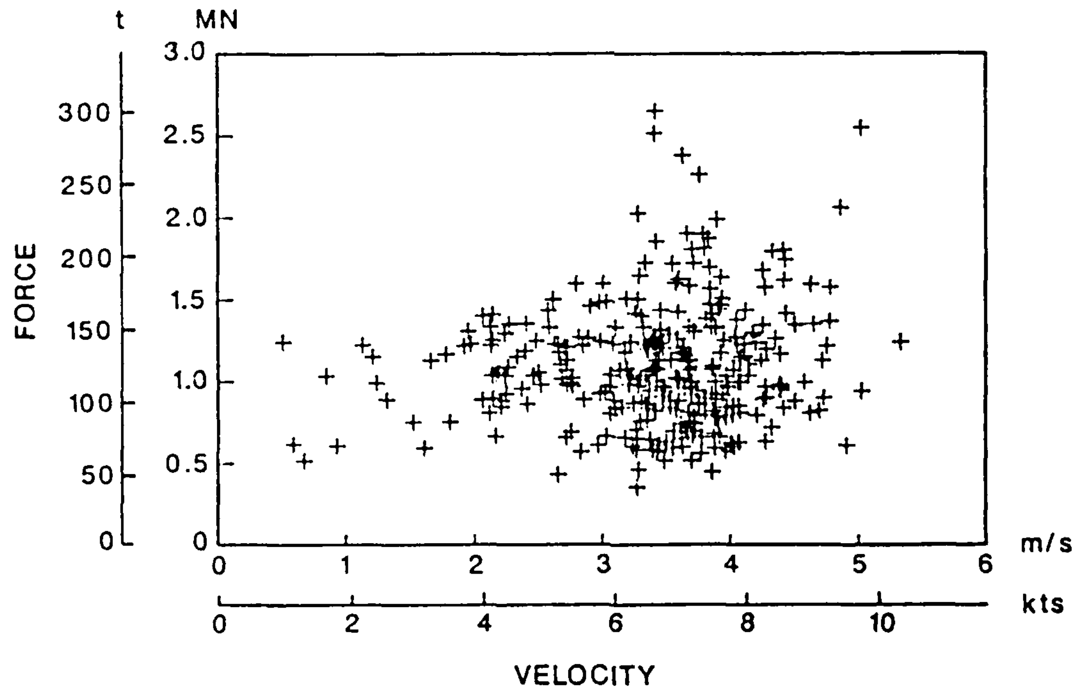
3.3 Force versus Velocity

Analytical models of ice impact mechanics predict a clear relationship between force and velocity [5, 6]. Figure 9a shows the force versus velocity data for the POLAR SEA for the North Chukchi Winter 83 data set. The maximum force for each event (one data point per event) is plotted against initial impact speed. No clear trend with velocity is evident in the data. Figure 9b shows the same data for the Antarctic Summer 84 data set. In the latter case, there does appear to be an increase of force with increasing velocity, however the trend could be masked by the fact that the data were collected in varying ice thicknesses from 3 to 6 feet (1 to 2 m) and the actual ice thickness for an individual impact is not known. In the former case, the ice conditions included a range of first-year and multi-year floes with widely varying thicknesses. With such a range of ice conditions and the tendency for operators to be more cautious in heavier ice, it is not surprising that no clear trend was found. It is evident that both high and low forces occurred at all speeds. Speed control (other than that which was already imposed) would not have lowered the force levels.

Two general conclusions can be drawn from this data. One is the need to collect ice properties data in as much detail as possible. Secondly, unless detailed ice geometry and properties data exist, only statistical analysis of the data is valid. Statistical values can be derived from the data that describe the ship impact process in an overall sense. This work has been done and is presented in Section 4.



a. NORTH CHUKCHI - WINTER '83



b. ANTARCTIC - SUMMER '84

Figure 9

TOTAL FORCE VERSUS IMPACT VELOCITY

4. STATISTICAL ANALYSIS OF THE DATA

4.1 The Shape of the Ice Impact Pressure-Area Curve and its Effect on Ice Load Development

During the course of data reduction and analysis of four deployments of collected data comprising over 2000 impact events, a multitude of pressure versus area plots were produced. These include plots for each time step throughout an event, plots at the time of peak pressure and peak force during each event, and plots of the highest recorded pressure over each area for all events in a data set. One significant fact emerges; the pressure-area curve has a consistent and characteristic shape whether it is for one instant of one impact or the extreme envelope of many impacts.

The implications of this finding have a profound effect on simplifying a statistically based ice impact load algorithm. The pressure-area curve is typically plotted on a log-log scale as shown in Figure 10. At small impact areas, pressures tend toward a line which decreases slightly with increasing area. At large impact areas, the average pressure becomes force limited and tends toward a line proportional to the reciprocal of area. The upper line or the pressure asymptote has a constant slope on this type of plot that is determined by area to a power in the range of -0.2 and -0.3. Events occur randomly and the effect is to shift the asymptotes up or down, or to the left or right, depending on the severity of the impact and the type of ice encountered. If the average pressure over a small area is independent of the total force during an impact, each can be predicted statistically from measured data to determine the asymptotes of the pressure-area curve. The complete design curve at all areas can therefore be generated from two lines of constant slope, one associated with a limiting pressure and one with a limiting force.

The slope of the limiting pressure line was determined from a number of sources. First, envelope pressure-area curves from a number of measured data sets are shown in Figure 11 for a wide range of areas. As one can see a line of area to the -0.2 power fits the limits of the data well. Secondly, Figure 12 presents an analysis of the extreme events from the 1982 Summer Beaufort Sea deployment. Data from the pressure-area curves for these events up to 6 sub-panels was non-dimensionalized and plotted in the figure; that is, the ratio of the highest average pressure over 3 sub-panels to that over 1 sub-panel is plotted against the ratio of the areas (3), for instance. Most combinations of sub-panel ratios are considered in the plot up to 6 sub-panels. One can see that the upper bound of the data approaches a limiting slope of area to the -0.2 power.

There is an apparent correlation with theory as well. If it is assumed that the impact pressure (P) is proportional to compressive ice strength [12] and ice strength (σ_c) is proportional to strain rate ($\dot{\varepsilon}$) to a fractional power b [13], then it can be shown that pressure is proportional to area to the -b power for certain shaped indenters. Unconfined crushing strength shows this behavior at low strain rates. At the high strain rates normally encountered in ship/ice impacts, unconfined crushing strength becomes constant, but triaxially crushing strength continues to exhibit this relationship with the same fractional power as the unconfined case at lower strain rates.

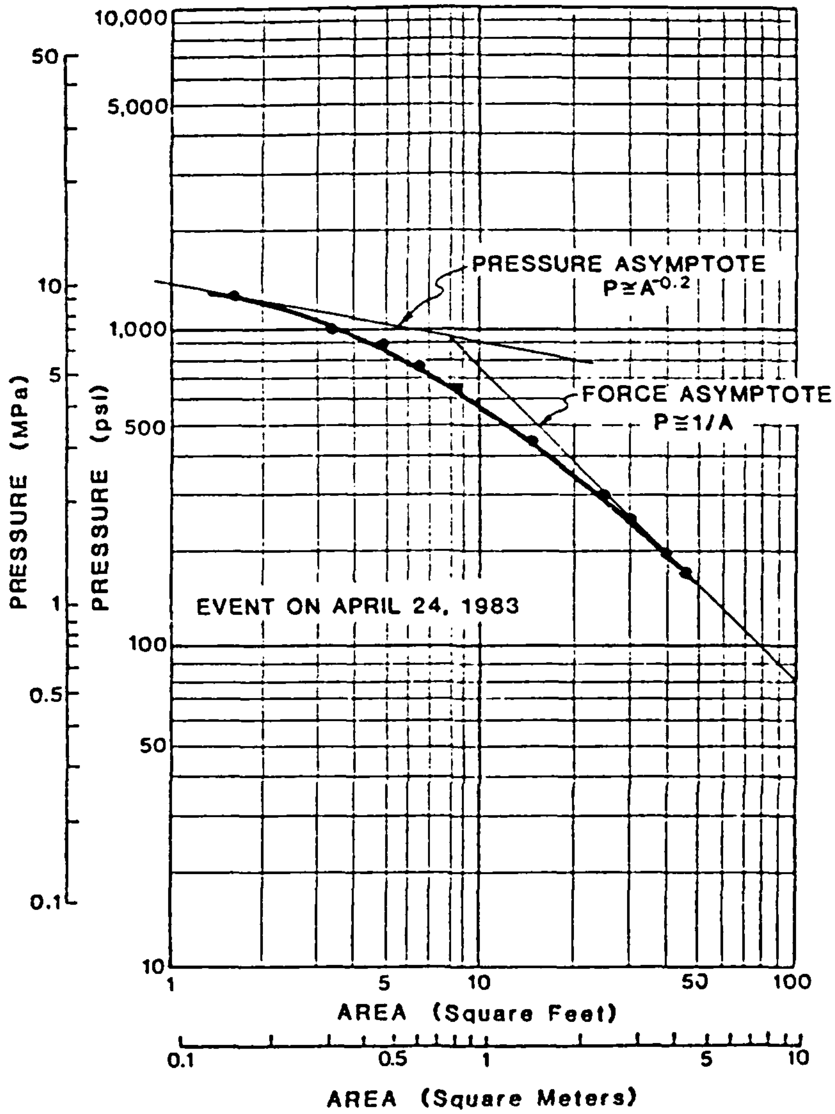


Figure 10

A TYPICAL EVENT SHOWING THE ASYMPTOTIC NATURE OF ICE IMPACTS

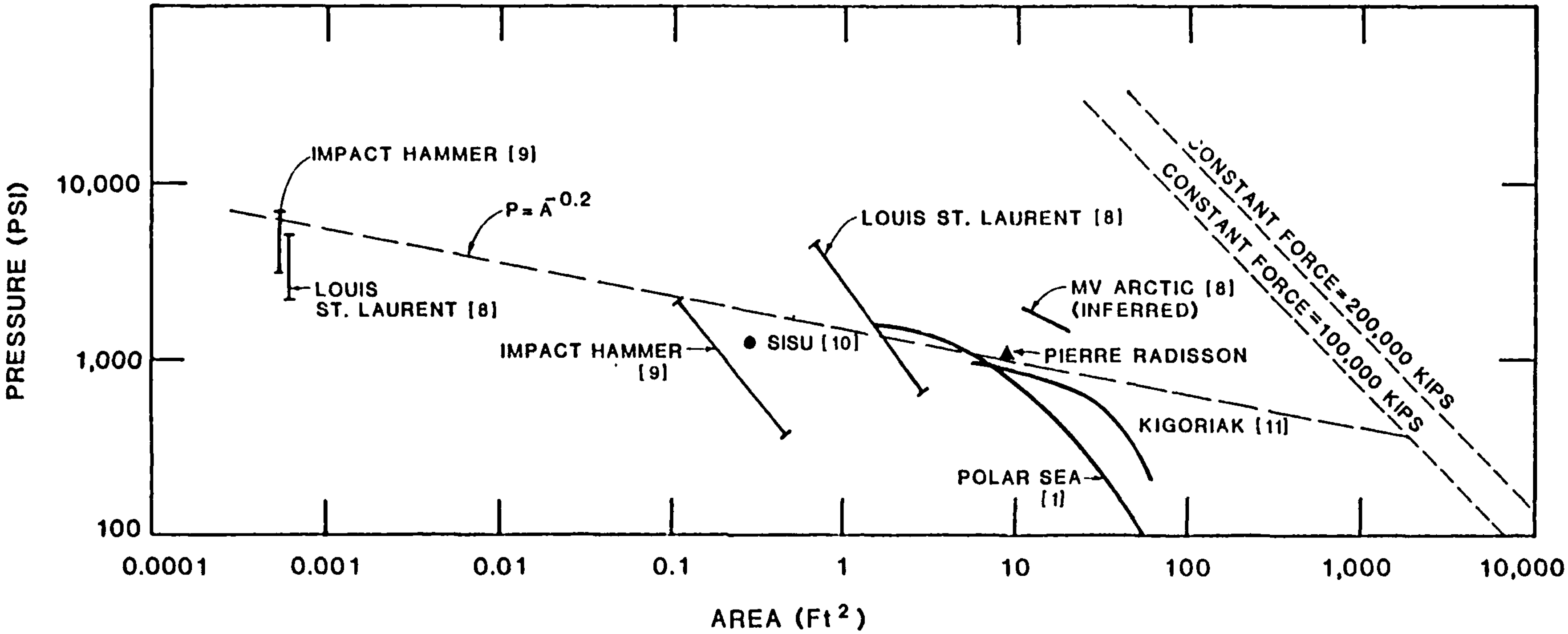


Figure 11

COMPARISON OF THE PRESSURE ASYMPTOTE WITH MEASURED LOCAL CONTACT PRESSURE DATA

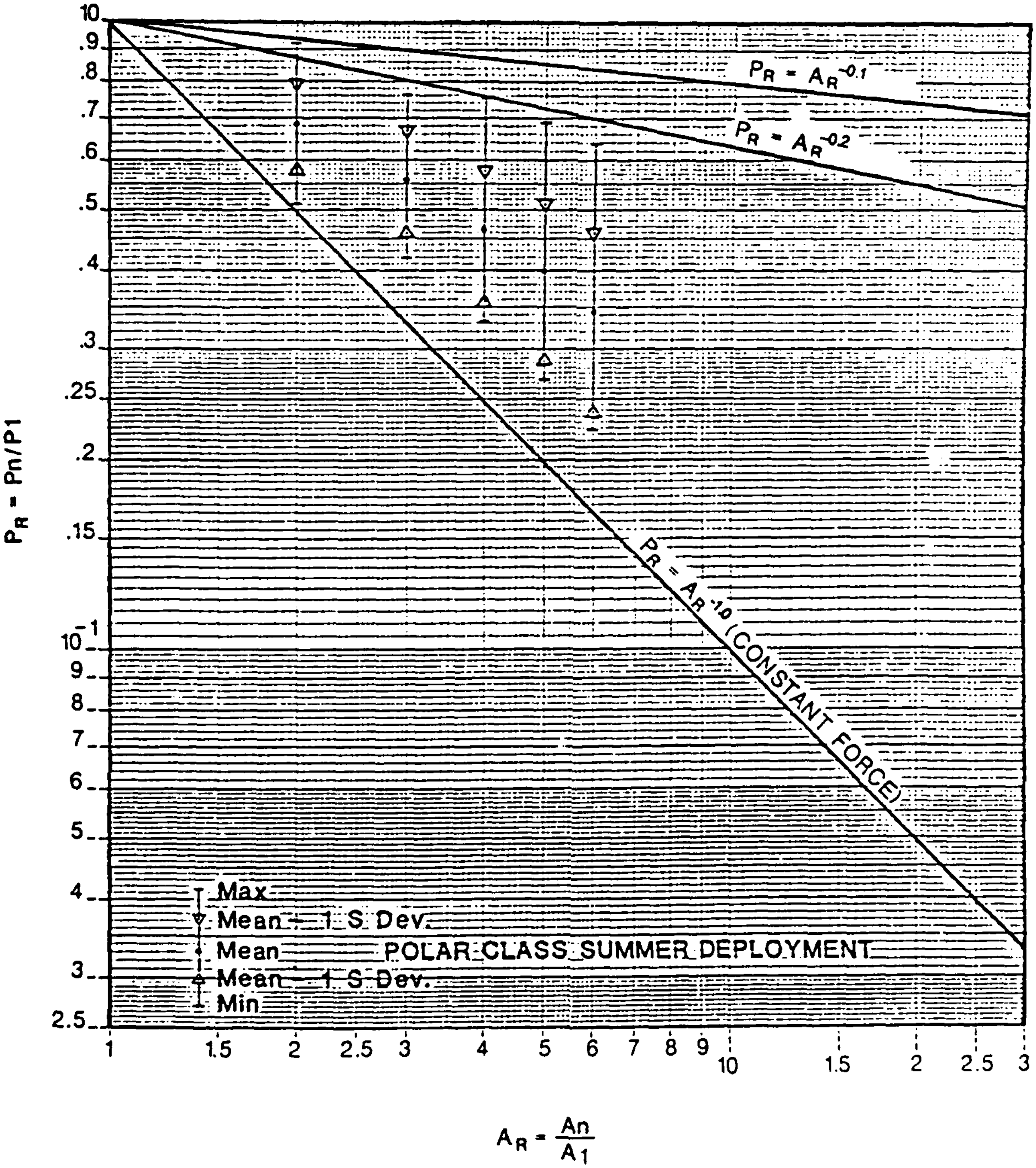


Figure 12

NON-DIMENSIONAL ANALYSIS OF PRESSURE-AREA DATA FROM THE BEAUFORT SUMMER 82 DATA SET

Consider a spherical shaped indenter where the strain rate at the failure zone is proportional to:

$$\dot{\varepsilon} = \frac{u}{z}$$

where u is the indentation velocity and
z is the indentation distance

$$z = \frac{A}{2 \pi R} \quad \text{for small } z$$

where A is the contact area and
R is the radius of the indenter.

Therefore:

$$\dot{\varepsilon} \approx \frac{u}{A}$$

$$P \approx \sigma_c \approx \dot{\varepsilon}^b \approx u^b A^{-b}$$

A similar result occurs if it is assumed that the strain rate is proportional to the indenter velocity divided by the contact area.

Cox, et al. [13] presents uniaxial compressive strength data for multi-year ice from the Alaskan Beaufort Sea tested at different temperatures. The mean of the data taken at 23 degrees Fahrenheit (-5 degrees Centigrade) gives a value of 0.209 for b. This compressive strength data should be typical of the strengths of the multi-year ice that generated the ice impact loads. The slope of the pressure limit line predicted by this method is again very close to the -0.2 shown above. This is not to say that the complex interaction of impact of a ship's side with ice can be directly compared with spherical indentation or triaxial crushing tests, but this development does show an interesting correlation to the measured results.

4.2 Regression of Extreme Value Distributions

Individual impacts from all deployments consist, in reduced form, of time-histories of the average pressure over each of the sixty sub-panel areas within the load panel. During data reduction, each sub-panel time-history is scanned to identify the time of highest average pressure over any of the sub-panels during the event and the time of peak force on the entire panel. The corresponding pressure and force are also noted. Pressure versus area relationships are developed for both of these times during the event by identifying the highest pressure on any sub-panel at that time, checking all contiguous areas for the next highest pressure and so forth until all loaded areas have been identified. Since each sub-panel area is the same, 1.63 ft^2 (0.15 m^2), the result is a tabular listing of the decay in average pressure as a function of the number of sub-panels that are contiguously loaded at the time of peak pressure and peak force for each event. The number of sub-panels can easily be multiplied by the sub-panel area to produce plots of pressure versus area at a given instant of time as shown in Figure 10.

Additionally, the highest load along a frame or stringer was also computed since the sub-panel width was the frame spacing (16 in or 400 mm) and the sub-panel height was almost the frame spacing (14.7 in or 375 mm). For the load on the frame, the highest average pressure on a single sub-panel was located first, then the highest average pressure over two adjacent sub-panels arranged vertically one above the other, and then three adjacent sub-panels in a vertical line. The process continued for each number of sub-panels up to six in a vertical line, the total height of the array of sub-panels in the bow panel. The force for each was computed as the average pressure times the corresponding measurement area. The force remained relatively constant regardless of the length of the measurement area (high pressures over short lengths and low average pressures over longer lengths) but the maximum typically occurred at a length of about half the panel height. The fact that the force is relatively constant for all frame lengths allows a single value of force to be used to characterize each event. The fact that the maximum force on a frame occurred at a span roughly half the height of the panel means that the limited panel height was sufficient to capture the maximum load on the frame and should not effect the extreme value analysis. A similar process was done for adjacent sub-panels in a horizontal line, assuming the ship was longitudinally framed. The force versus stringer length for up to 10 sub-panels arranged in a horizontal line, the bow panel length, was computed and the highest was saved for the extreme value analysis.

The above described procedures have been performed as part of the data reduction process for each event on each deployment. The statistical analysis conducted for and described in this report starts with this data as well as the peak force on the entire panel for each event as its basis. The highest average pressures over one and four sub-panels from the pressure-area curve and the peak forces on a frame and stringer as well as the force over the total panel were analyzed statistically. Events were divided into data sets based on geographic area of operation or ice conditions as described in Section 2. Each of the five variables was identified for the events in each set of data and ranked from highest to lowest. The corresponding probability of non-exceedance was computed based on the formula:

$$\text{Probability} = 1-I/(N+1)$$

where I is the rank of the variable in the data set and N is the number of events in the data set.

A three parameter extreme value distribution was then fit to the pressure or force versus probability data [14]. The curvature parameter in the extreme value curve fit is an indication of the type of asymptotic distribution as described in Appendix B. Three types of distributions are possible [15]; a Gumbel (Type I) which is unbounded and linear on extreme value probability plots, a Frechet (Type II) which is unbounded and linear on log-extreme value plots, and a Weibull (Type III) which has an upper bound. The trends in the parameters of the distribution and therefore the type of distribution with respect to ice conditions have been studied and indicate that the more severe ice conditions have a Frechet type distribution. As ice conditions decrease in severity, a Gumbel type extreme value distribution appears to be more appropriate. First-year ice conditions often exhibit an upper bound in extreme loads, indicating a Weibull distribution gives the best fit to the data. Appendix C gives plots of the extreme value distributions for the five variables studied as well as the corresponding three parameter curve fits. Tables of the curve fit parameters are shown in Appendix D. Correlation coefficients for the curve fits were typically 0.98 or higher indicating an excellent fit to the data.

Figure 13 shows the single sub-panel pressure data from the North Chukchi Winter 83 data set as an example. Also plotted is the Gumbel distribution computed graphically for 386 of these events in the 1983 report describing this data collection [1]. As one can see, the three parameter curve fit indicates a Frechet (Type 2) extreme value distribution, due to the upward curvature. The curve fit of reference [1] is slightly below the full data set because only a portion of the data was used in the initial analysis. Extrapolation to longer return periods using the reference [1] curve fit would under-predict the extreme pressure substantially compared with the three parameter curve fit.

Figures 14 and 15 show a comparison of the highest average pressure over one sub-panel and the highest force on the entire panel extreme value distributions, respectively, for different geographical areas in the Alaskan Arctic. Figures 16 and 17 show corresponding distributions for different ice conditions. The relative increase in the severity of the ice loads with increasing latitude and increasing severity of ice conditions is apparent in the figures.

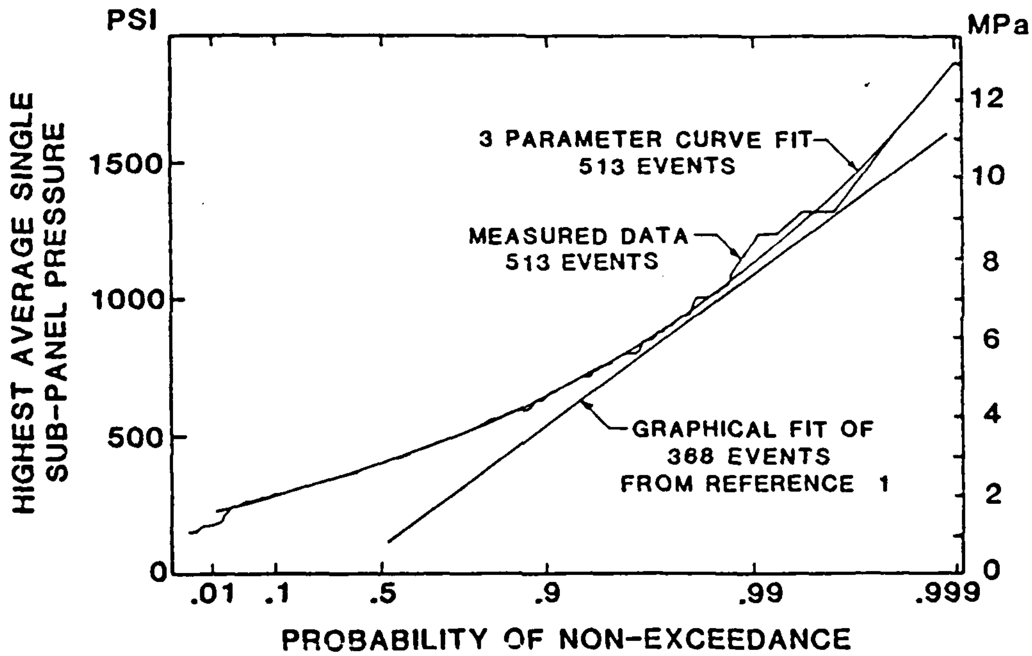


Figure 13
EXAMPLE OF THE 3 PARAMETER CURVE FIT OF THE NORTH CHUKCHI WINTER 83 DATA SET

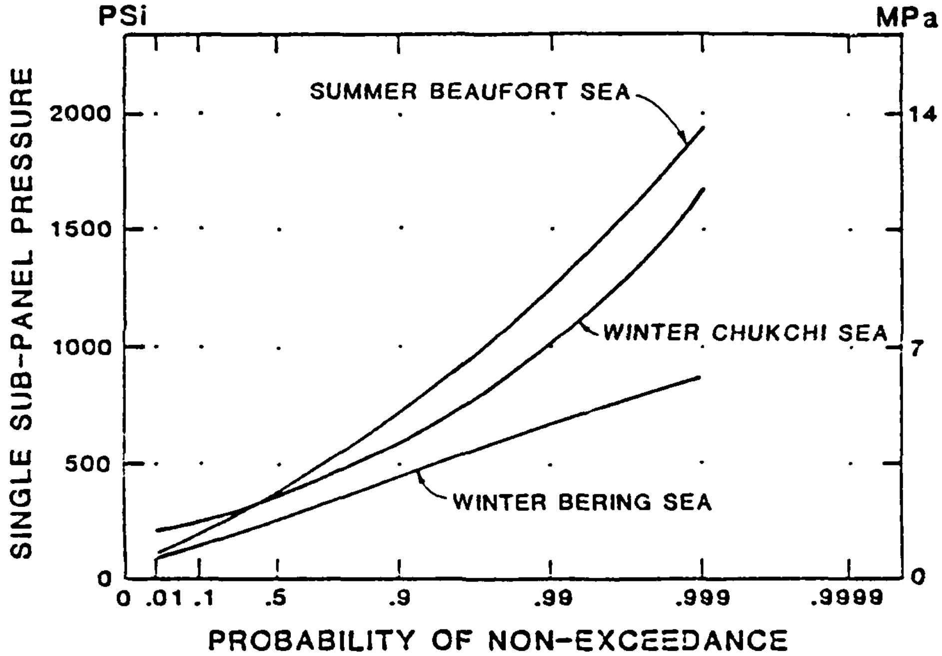


Figure 14
COMPARISON OF SINGLE SUB-PANEL PRESSURE FOR DIFFERENT GEOGRAPHICAL AREAS

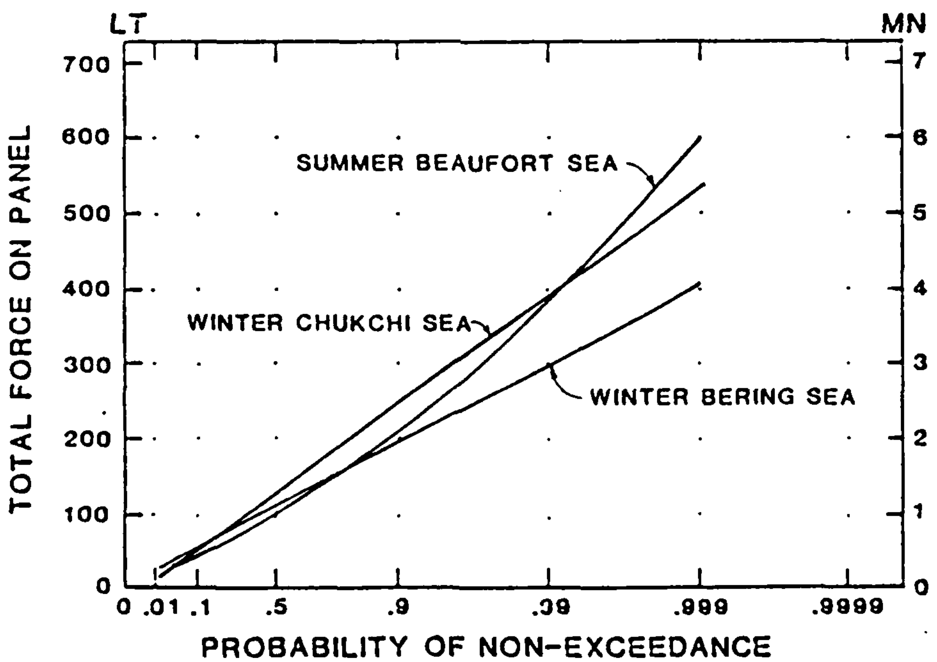


Figure 15
COMPARISON OF TOTAL PANEL FORCE FOR DIFFERENT GEOGRAPHICAL AREAS

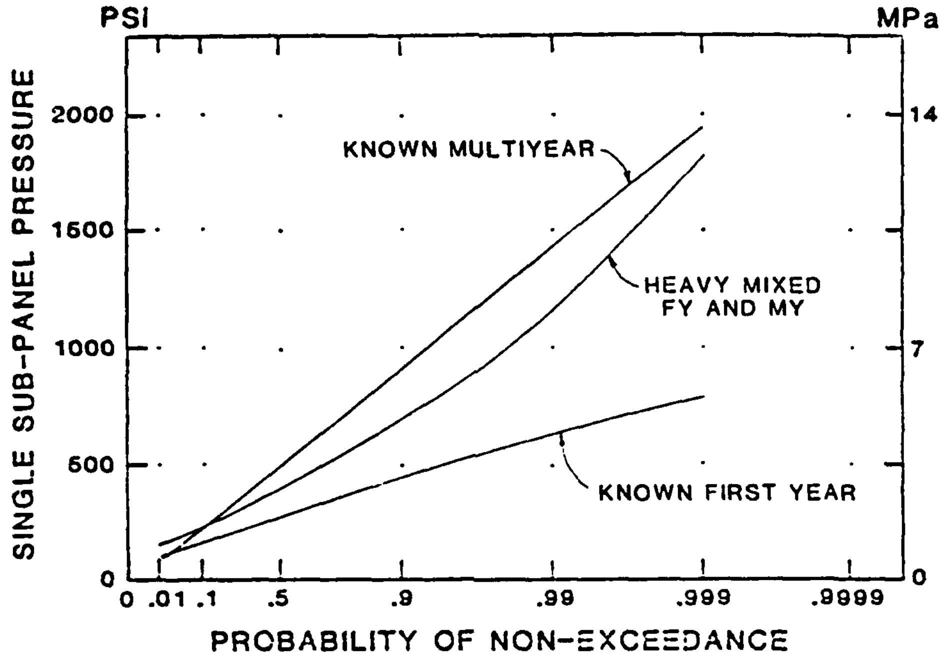


Figure 16
COMPARISON OF SINGLE SUB-PANEL PRESSURE FOR DIFFERENT ICE CONDITIONS

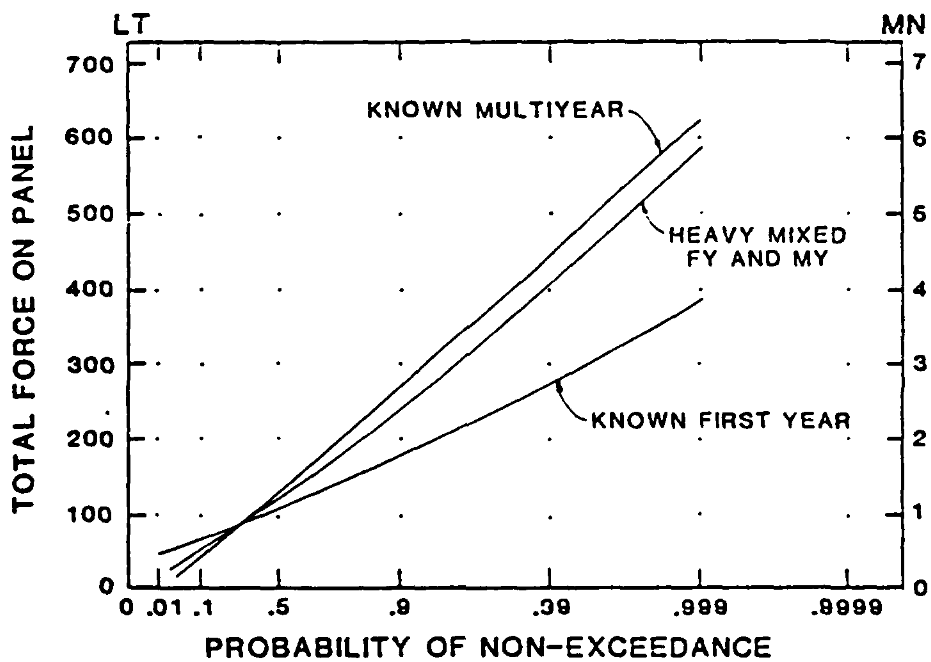


Figure 17
COMPARISON OF TOTAL PANEL FORCE FOR DIFFERENT ICE CONDITIONS

4.3 Application to a Design Procedure

Section 4.1 described the asymptotic nature of the pressure versus area curve, for a single instant of time, observed from the measured data. That section also showed that the slope of the pressure asymptote appears to fall within a narrow range of values related to the crushing strength versus strain rate behavior of the impacted ice. If the slope for the pressure asymptote is defined by the type of ice, then the extreme value distribution for single sub-panel pressure can be used to estimate the highest expected pressure in a given return period for one contact area (1.63 ft^2 or .15 m^2) and thus define the location of that asymptote on the pressure-area curve. The force asymptote can be similarly determined from the extreme value distribution of force using the same return period. Since average impact pressure equals the impact force divided by the contact area, the force asymptote plots as a 45 degree line on a log-log pressure-area curve (see Figure 18).

But which force distribution should be used? The extreme value distributions described in Section 4.2 and given in Appendix C are a characterization of the forces over very specific areas and, additionally, very specific shaped areas. The total panel force is measured over the entire instrumented panel; an area of 98 ft^2 or 9.1 m^2. The panel dimensions are 7.3 feet high by 13.3 feet long (2.24 by 4.07 m). The force on a frame data used in the distribution are the highest force for each event computed from the pressure versus length along a frame described in the previous section. This force is considered to act over a vertical strip of hull plating 16 inches (400 mm) wide and up to the height of the panel high. Similarly, the force on a stringer is assumed to act over a horizontal strip along the hull that is 14.7 inches (375 mm) wide and up to the length of the panel in length. For local ice impact load development, i.e. the determination of loads for plating, frames and stringers, the force on a frame for transversely framed ships and the force on a stringer for longitudinally framed ships should be used. The force distribution must be consistent with the loaded area of the scantlings for which it will be used.

The distributions of total force on the panel and highest average pressure over four sub-panels also given in Appendix C are included for completeness. The total force distribution indicates the magnitude that ice forces can reach for bow contact areas up to 98 ft^2 (9.1 m^2). The panel did not measure total bow force, however, since some of the shell plating was obviously loaded outside the instrumented panel. Large area loads such as those that might be useful for design of girders, decks and bulkheads are therefore best determined either from global load measurements or analytical models that estimate total bow force. The measured data indicate that a contact area corresponding to four sub-panels is about where the intersection of the force and pressure asymptotes occur (see Figure 18). This is the part of the pressure-area curve where the actual pressure deviates most from the asymptotes. The four sub-panel distributions give an indication of the magnitude of this deviation, therefore.

To summarize, the extreme value distributions of the measured data can be used to develop a pressure versus area curve that describes the highest expected ice impact pressure in a given return period for the range of impact areas associated with local hull scantlings. The data presented in Section 4.2 is only appropriate to hullforms of similar size and shape to that of the POLAR Class and framing systems of similar spacing to that described here. Application of this approach to other ship designs will be discussed in the following section.

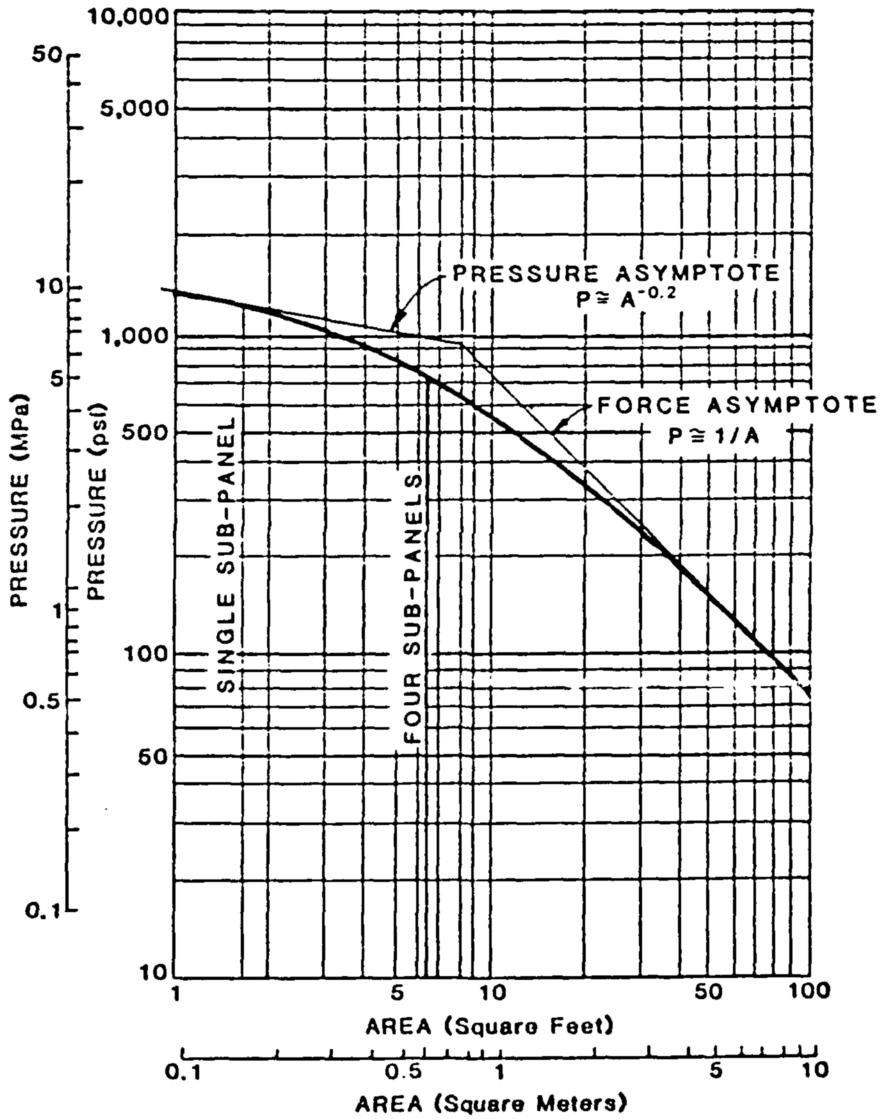


Figure 18

EXAMPLE OF HOW A PRESSURE-AREA CURVE CAN BE GENERATED FROM THE STATISTICAL DISTRIBUTIONS

5. RECOMMENDATIONS FOR LOCAL ICE LOAD DESIGN CRITERIA

5.1 Bow Structure Load Criteria

It is the opinion of the authors that two conditions or return periods should be considered when developing the ice loads for design; the normal operating condition (loads in the range of one to three year return period) and the survival condition (lifetime loads). Normal operating loads should cause no deterioration in the ship's operating performance while survival loads may cause some loss of performance but not catastrophic failure.

To develop the loads for each loading condition, the expected number of impacts must be estimated for the time period by conducting an operational assessment of the ship in the ice conditions in which it will operate. Table 3 gives a summary of the frequency of impacts for the collected data to assist in this estimate. The reciprocal of the number of impacts expected is the probability of non-exceedance used to enter the figures in Appendix C for the loads. The single sub-panel pressure establishes one point on the pressure asymptote (see Figure 18). The maximum force on a frame or stringer distributions establish the force asymptote, depending on whether the ship is transversely or longitudinally framed, respectively. It should be noted that the normal operating condition will be associated with a relatively small number of impacts which fall within or just beyond (slight extrapolation from) the measured data. This is not usually the case with survival loads; the number of impacts may require a large extrapolation from the existing data base of measured loads. There is typically a much higher confidence in the normal operating loads, therefore.

An example will be presented to help illustrate the proposed procedure. Assume that an icebreaker is being designed for operation in the Northern Bering Sea and is expected to be underway there for two winter months out of the year. It is expected to operate 12 hours per day during this time. The annual number of impacts is estimated to be:

8.2 impacts/hr X 12 hr/day X 60 days/yr = 5904 impacts/yr

See Table 3 for measured impacts per hour in different operating areas. If the normal operating loads are taken as those expected annually, the probability to enter the distributions for N Bering Winter 83 (Appendix C) is one minus the reciprocal of 5904 or .99983. The graphs of the distributions can be used directly or, more accurately, the equation for the three parameter curve fit can be used:

$$\text{Result} = [1-(-\ln(\text{Probability}))^{C}]\,(A2/C) + A1$$

The coefficients from Tables D1 (single sub-panel pressure) and D4 (force on a frame) are:

	C	A1	A2	RESULT	
Pressure	.026	289 (1.99)	84 (0.58)	942 (6.49)	psi (MPa)
Force on a Frame	-.239	36 (0.36)	11 (0.11)	356 (3.55)	LT (MN)

These results are shown graphically in Figure 19. The authors recommend using the average pressure over an area equal to the frame spacing squared as the design pressure for plating. For a 16 inch (400 mm) frame spacing, the pressure is slightly less than the result shown above since the sub-panel measurement area was slightly smaller than the frame spacing squared. The results can be scaled by the factor $[(16 \times 16)/(144 \times 1.63)]^{-0.2} = .983$ to obtain the plating design over the frame spacing squared (926 psi or 6.38 MPa for this example). Design pressures for frame design can be taken from Figure 19 for this example using an area of the frame spacing times the loaded length along the frame. A loaded length equal to the frame span will result in a low uniform pressure over the entire span while choosing a shorter loaded length will result in a higher uniform pressure over a shorter length, presumably the limiting design condition.

The measurement panel that recorded the data presented in the previous chapters was located in the bow of the POLAR SEA. Load criteria based on the measured data can only be developed for the bow therefore. Extension of these loads to other areas of the ship will be discussed in the next section.

TABLE 3

FREQUENCY OF OCCURRENCE OF IMPACT EVENTS FOR THE MEASURED DATA

DATA SET	TYPICAL THRESHOLD ($\mu\varepsilon$)	AVERAGE IMPACT FREQUENCY (events/hr)	RECORDING TIME (hrs)	TOTAL ELAPSED TIME (hrs)	NUMBER OF IMPACTS
Beaufort Summer 82	250	3.2	52.2	314.4	167
S Bering Winter 83	75	10.5	16.5	29.0	173
N Bering Winter 83	120	8.2	29.5	48.5	241
S Chukchi Winter 83	120	4.4	68.0	206.5	299
N Chukchi Winter 83	150	3.6	143.0	617.0	513
Antarctic Summer 84	100	21.0	15.0	15.0	309
Beaufort Summer 84	150	4.9	68.8	325.5	337

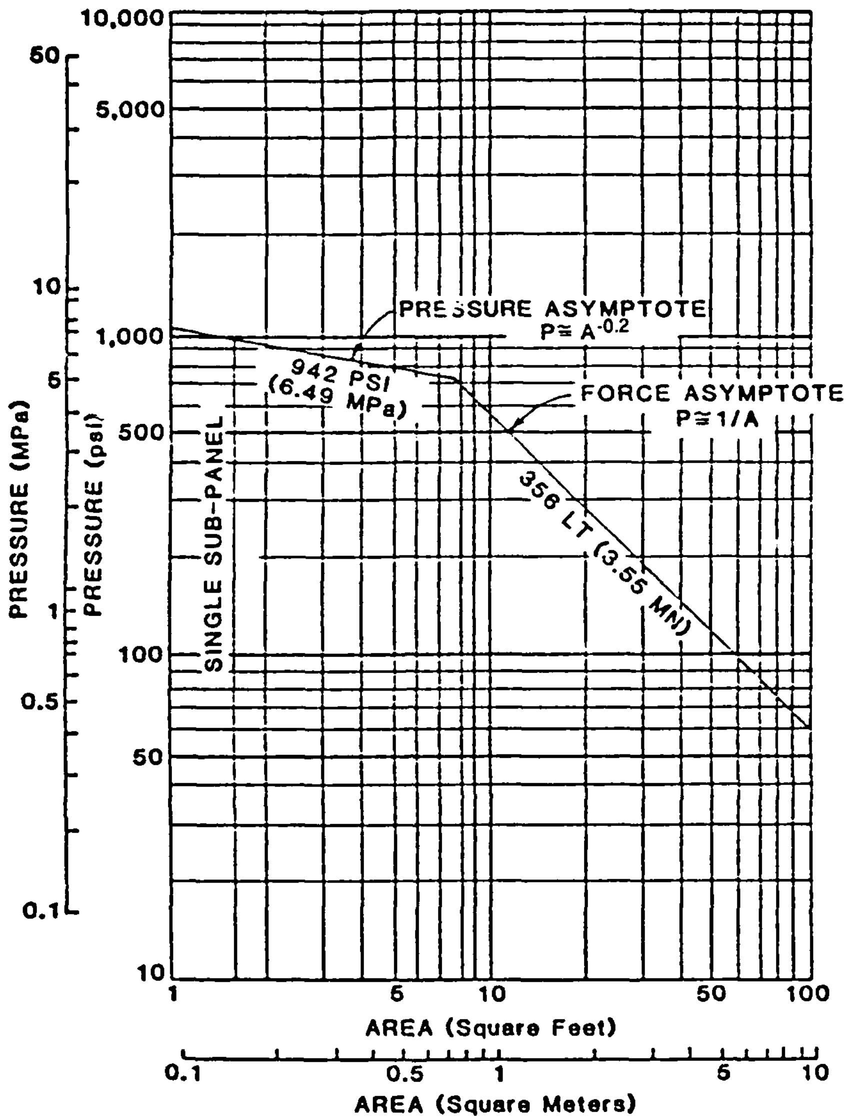


Figure 19

PRESSURE–AREA CURVE FOR THE EXAMPLE
(Northern Bering Sea Icebreaker)

5.2 Extension of the Criteria to Other Areas of the Ship

Measurement of hull-ice impact loads has concentrated on the bow of icebreaking ships since this is where the highest local loads occur. The bow area is normally considered to extend to the point of maximum beam though some reduction in impact pressures is expected near the shoulders due to the relatively low angles of incidence with the ice. Section 5.3 will discuss the effect of hull shape on the local ice loads. This section will deal with the areas aft of the forwardmost point of maximum beam which are generalized as the amidship area and the stern area. Specific ice impact loads have not as yet been measured in these areas of an icebreaking hullform. Guidelines that exist are based on theory or experience or both.

The stern area will be addressed first since it can more directly be related to bow loads. Previous sections stated that the pressure asymptote of the pressure-area curve appears to be largely independent or very weakly a function of impact speed, however the force asymptote is linearly related to impact speed. One would therefore expect that if the maximum astern speed was some percentage of the maximum forward speed in heavy ice conditions, say 30 to 50 percent, then the force on a frame or stringer values would be reduced by a similar factor relative to the bow forces. This results in a shift of the force asymptote to the left on the pressure-area curve as shown in Figure 19. The pressure asymptote remains the same indicating that average impact pressures over very small areas are expected to be equivalent to pressures over the same area at the bow. This probably means that frame design loads will be reduced more than plating design loads relative to the bow (presuming that the bow plating is determined by the pressure asymptote). An astern shape similar to the bow shape has been assumed. While this may be a good assumption for a conventional icebreaker like the POLAR Class, transom-sterned ships such as many of the icebreaking supply boats that have been built recently will probably require additional corrections for local hull angles.

For the amidship area, the problem is more complex. The ice impact speed normal to the hull in the midship area is small for straight ahead icebreaking. While the normal velocity can increase in turns or when the ship is maneuvering, the limiting load is almost certainly due to a pressured ice condition. Pressured ice conditions can occur when the ship is moving, however, the greatest large area average pressures are most likely when the ship is beset. Several theoretical solutions have been advanced for the load per unit length that can be developed in an ice sheet under pressure. These are grouped in two categories (summarized in References 16, 17) known as ridge building forces, the load that causes failure in the ice sheet, and limiting driving force, the load that can be developed due to wind and current loads. The maximum force per unit length that exists in an ice sheet is the minimum of the two solutions; that is, if the driving force causing the pressure exceeds the load carrying capacity of the ice sheet, then the ice sheet will fail limiting the load to the failure value. Several of the solutions are shown in Figure 20 for the load on a multi-year floe in a three foot thick pressured ice sheet. It should be noted that driving force is limited by the first-year ice cover, the weakest part of an ice field that may contain multi-year floes of much greater thickness. The same loads could be seen by a ship beset in these conditions.

Figure 20 shows that loads range from 20 LT/ft (0.66 MN/m) to over 100 LT/ft (3.3 MN/m) depending on the loaded length and the thickness of the ice cover. But these loads are global in nature, those that are expected over the length of the waterline. Local impact pressures recommended by various classification societies for the midship area are approximately sixty percent of bow design pressures. Canadian Arctic Shipping Pollution Prevention Rules (CASPPR) [18] recommend 63 percent, the USSR Rules [19] recommend 60 percent and the new American Bureau of Shipping (ABS) Rules [20] recommend 50 to 60 percent for icebreakers depending on ice class.

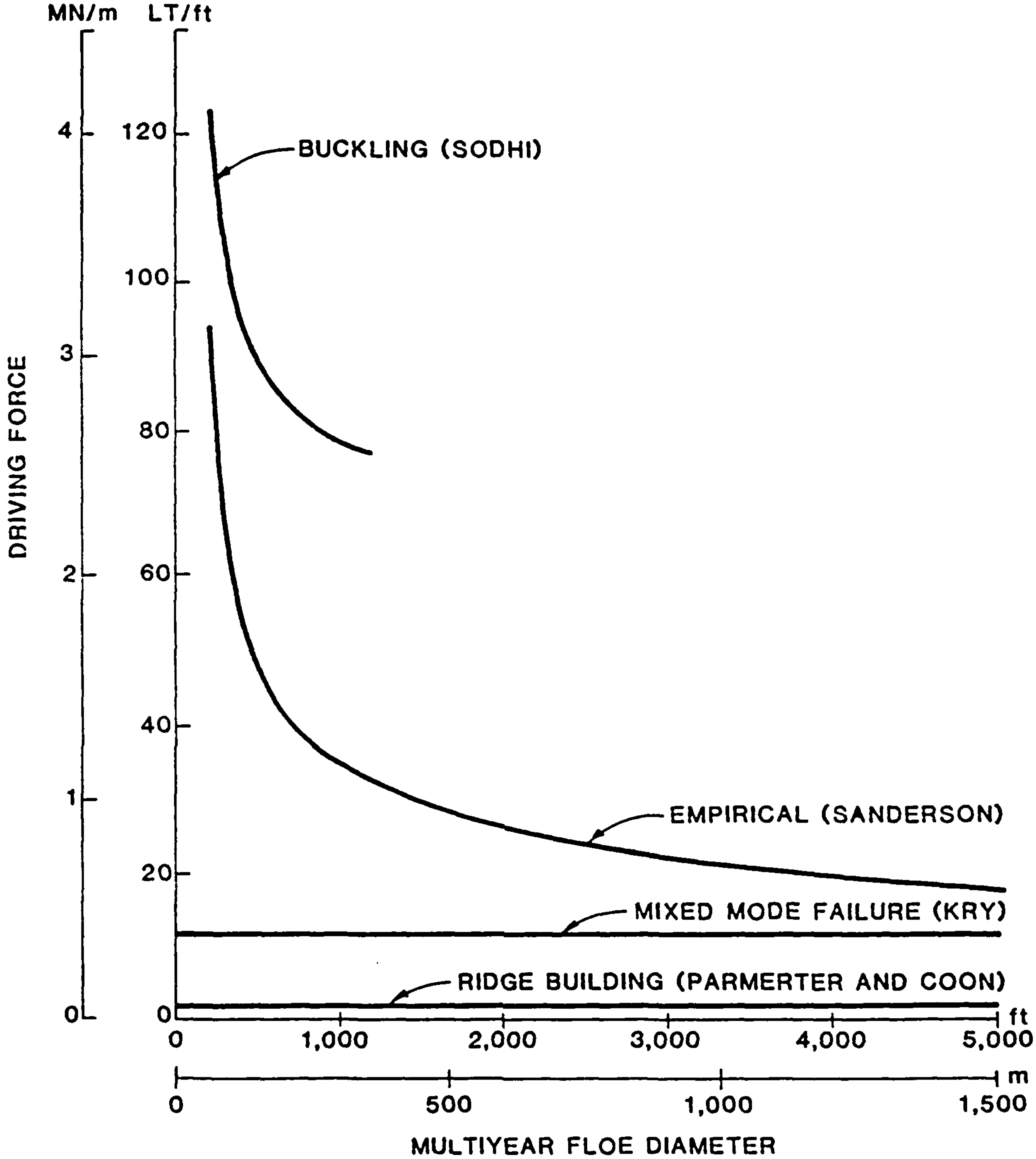


Figure 20

ESTIMATES OF LIMITED DRIVING FORCE ON A MULTIYEAR FLOE
SURROUNDED BY 3 FOOT THICK
FIRST YEAR ICE

5.3 Areas for Improving the Load Criteria

Certainly one area for improving ice load criteria is measurement of local ice loads in locations other than at the bow. Section 5.2 discussed ways to apply the data base of measured bow loads to other areas of the hull which are based on theoretical development and experience. Measured loads, especially in the midship area, would not only verify these methods but also provide a better understanding of the ice-structure interaction as well. The slow speed impact loads that might be experienced by the midbody of a ship in the beset condition also have application to offshore structures and, conversely, measured data on offshore structures might be useful in studying the ship problem.

Two other areas of improvement must be considered to properly address the full range of icebreaking ship sizes and hull impact locations. The first is the aspect of the effect of local hull angles on the resulting loads. Both the ABS and Russian Rules incorporate a theoretical solution of the effect of local hull angles. Figure 9.2 of the new ABS Rules [20] is reproduced in Figure 21. The figure shows the variation in non-dimensional force with changing waterline half-angle (α) and local section angle (β) measured from the vertical. The values of these variables at the location of the measurement panel on the bow of POLAR SEA were α = 30 degrees and β = 54 degrees. The resulting non-dimensional load factor is 0.9. One can obtain an estimate of the expected loads at a location with different hull angles by reading the load factor for the location from Figure 21, dividing the factor by .9, and then multiplting the result by the statistically derived pressure of Section 4 appropriate to the ice conditions being considered. Experimental verification of the underlying theory would increase one's confidence in the validity of the predicted results, however.

The second area is the effect of the ship's displacement and power on the resulting loads. Johansson [21] proposed a relationship for ice impact pressure (P) as a function of the ship's power (N) and displacement (Δ) as:

$$P = P_0 + c(N\ \Delta)^b$$

where P_0 and c are constants and b is 0.5 in his work developing the Finnish-Swedish Rules [22] and later modified the exponent b to 0.33 for Arctic LNG tankers [23]. In his discussion of the latter, Tunik [24] recommended the expression:

$$P = P_0 + c\ N^{0.18}\ \Delta^{0.05}$$

based on the work of Kurdyumov [25]. More recently, in his work developing the new ABS Rules, Tunik has adopted an expression of the form:

$$P = c\ N^{0.2}\ \Delta^{0.15}$$

As more data is collected from ships of different sizes and with different available power, it will be important to try to validate these functional relationships. The task is very difficult however. Variations in ice conditions between different sets of measured loads can easily mask the effects of power and displacement. It is important to note that care must be used in scaling measured ice loads by these relationships as well, since the total available power is not always employed when the data are being collected. This is particularly true in the case of the POLAR SEA due to the flexibility of her propulsion plant. Each of her three shafts can be driven in diesel-electric mode up to 6000 HP or gas turbine mode up to 20,000+ HP. She is often operated in some combined configuration which could lead to erroneous results if scaling is based on total installed horsepower of 60,000 HP.

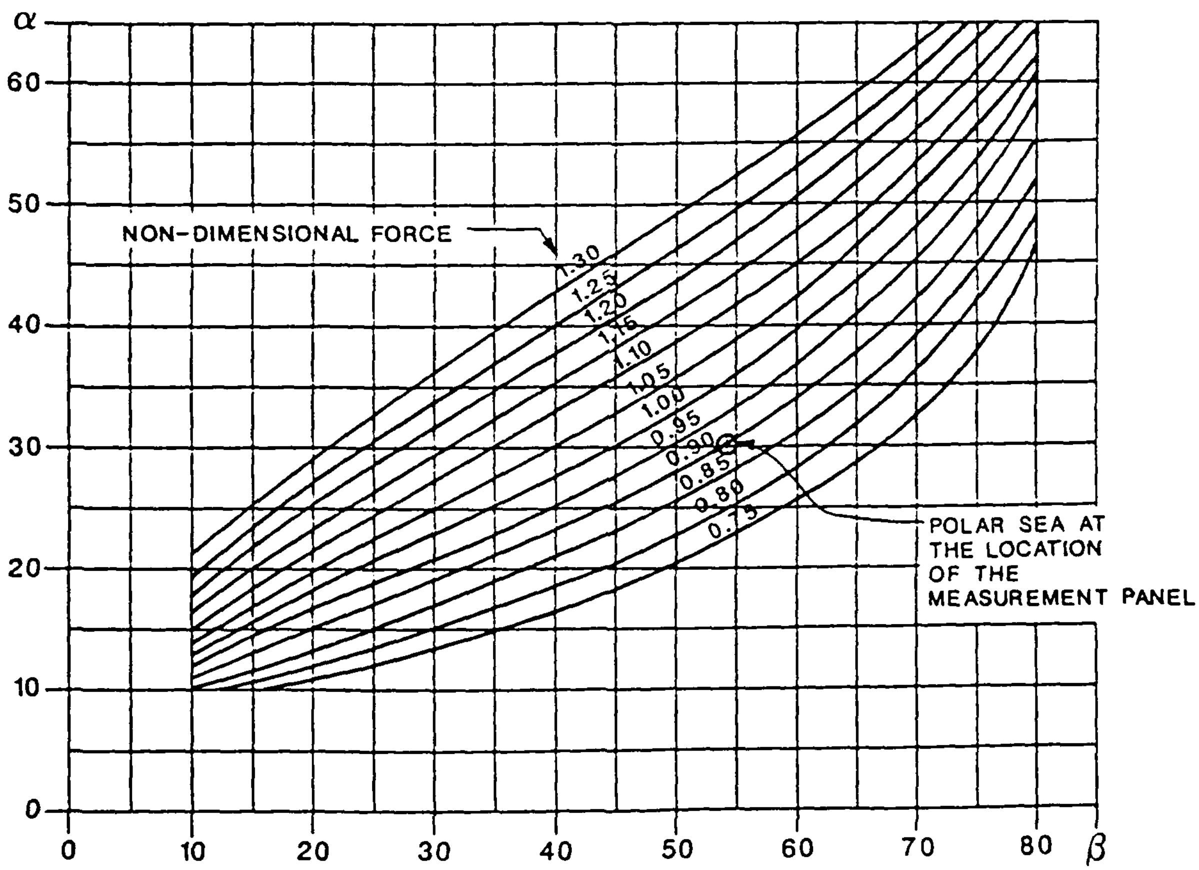


Figure 21

COEFFICIENTS FOR NON-DIMENSIONAL PRESSURE VARIATION WITH LOCAL HULL ANGLES

6. RECOMMENDATIONS FOR RESPONSE CRITERIA

6.1 Plating Response

A statistical description of the ice pressures and forces has been adopted. The previous section presented extreme value distributions of the loads, extreme pressures or forces versus the probability of non-exceedance. For a new design, the number of impacts expected in a given return period is estimated from an operational assessment of the ship's intended mission. Annual or several year loads might be considered operational; that is, those that are resisted with no deterioration in the ship's performance. A second return period, the desired lifetime of the ship, can also be considered. Loads for this time period represent survival loads; the ship should resist these with some probable reduction in performance but no catastrophic failure. Obviously, response criteria for the two loading conditions will vary with the ship and its intended use. A typical approach, however, might be to allow a small amount of permanent set for the plating and only elastic response of the framing under normal operating loads. Much more permanent set and even some plasticity in the framing could be considered under survival conditions.

A variety of theories and response criteria are available in the literature that could be considered for plastic response of plates. Figure 22 shows a comparison of plate response equations for the range from purely elastic response to rupture. The curves in the figure are computed for high tensile steel assuming a yield strength of 50,000 psi (345 MPa), an ultimate strength of 85,000 psi (586 MPa) and a 16 in (400 mm) frame spacing. The extreme left side of the figure (curve 14) shows an estimate of the load to cause rupture assuming a strain of 14 percent [30]. The right side of the figure (curve 1) shows the load to cause the yield stress assuming purely elastic response. Between are plotted a number of equations for plastic response to various levels of permanent set and, to the right side of the figure, the current response criteria of ABS (curve 2), the USSR (curve 3), and Canada (curve 4). It should be noted that all three of these response criteria use an equation of the form:

$$t = C\, s \sqrt{P/\sigma_y}$$

where σ_y is the yield stress, P is the uniform pressure, s is the frame spacing or plate span, and C is a coefficient that falls between the values of .707 for an elastic response (curve 1) and .5 for formation of three plastic hinges in a rigid-perfectly plastic model of an infinitely long plate with fixed end conditions (curve 7). The ABS and USSR rules add an additional 0.236 in (6 mm) to the resulting thickness (The value is less for other than the highest ice class) which accounts for their shift toward the elastic response curve.

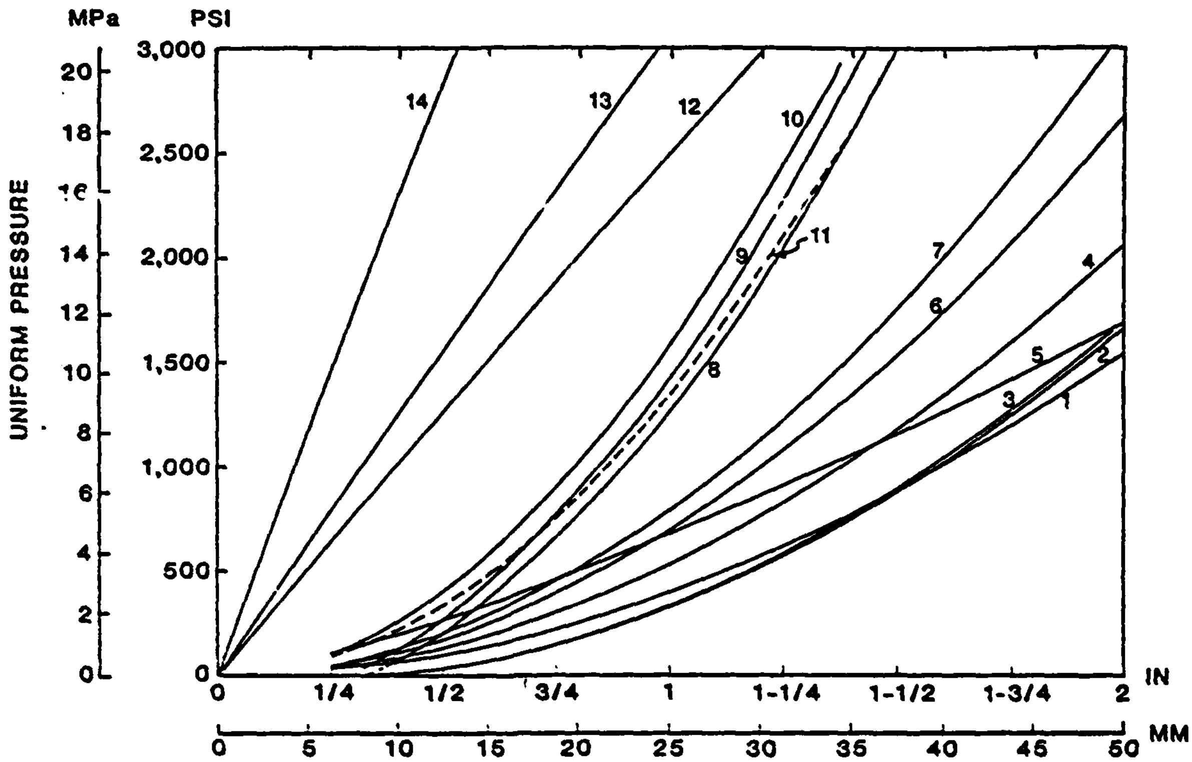


Figure 22
COMPARISON OF EQUATIONS DESCRIBING PLATE RESPONSE UP TO RUPTURE

(1) Elastic response, fixed end conditions, infinitely long plate [26].
(2) ABS Rules, 0.236 in (6 mm) corrosion allowance included [20].
(3) USSR Rules, 0.236 in (6 mm) corrosion allowance included [19].
(4) CASPP Rules, no corrosion allowance required [18].
(5) Clarkson, elastic-plastic, fixed end conditions, infinitely long plate, permanent set of the same order as welding deflections [27].
(6) Hughes, elastic-plastic, clamped, ends free to pull in, aspect ratio of 0.133 [28].
(7) Johansson & Jones, perfectly plastic, fixed ends, infinitely long plate, formation of three plastic hinges [21, 29].
(8) Chiu, Haciski and Hirsimaki, STAGS finite element model, fixed end conditions, infinitely long plate, permanent set is 0.3 percent of span [30].
(9) Chiu, Haciski and Hirsimaki, STAGS finite element model, fixed end conditions, infinitely long plate, permanent set is 0.5 percent of span [30].
(10) Jones, perfectly plastic, fixed ends, infinitely long plate, permanent set equal to plate thickness [29].
(11) Jones, perfectly plastic using the ultimate stress, fixed ends, infinitely long plate, permanent set equal to 10 percent of the thickness [29].
(12) Membrane response, edge springs, infinitely long plate, permanent set of 10 percent of plate span (Appendix E).
(13) Chiu, Haciski and Hirsimaki, membrane, pinned end conditions, infinitely long plate, permanent set is 10 percent of span [30].
(14) Chiu, Haciski and Hirsimaki, membrane, pinned end conditions, infinitely long plate, permanent set is 23 percent of span, estimate of rupture using a strain of 14 percent [30].

Also shown are Clarkson's (curve 5) and Hughes' (curve 6) elastic-plastic solutions. Curve 5 assumes an infinitely long plate with permanent set similar to that experienced during fabrication process. Hughes' equation allows for edge pull-in, which he and Ratlaff and Kennedy [31, 32] state is important for stout (small span to thickness ratio) plates typical of icebreakers. Hughes' equation includes the effect of plate aspect ratio which can also be significant as plate length becomes smaller. Curve 6 uses an aspect ratio of .133 or a plate length of 10 ft (3 m) for this example, since permanent set is included in the equation only if the aspect ratio is non-zero. A permanent set equal to 0.5 percent of the span has been used for curve 6. Chiu et al. recommend a maximum acceptable permanent set of 1 percent of the span [33]. Further, they state that a reasonable criterion for permanent set is the fabrication fairing criteria which is in the range of 0.3 to 0.5 percent of the plate span for icebreakers. The same paper also computes the load versus permanent set for a variety of plate thicknesses that might be used in icebreakers using a finite element model with non-linear material properties. A two-dimensional model, where the plate has pinned restraints at the frame locations, is used and the loading conditions include uniform loads over all and alternating frame bays. For the case where all frame bays are loaded (fixed end conditions), results are presented here in curves 8 and 9 for permanent set equal to 0.3 and 0.5 percent of the plate span, respectively.

Coburn, et al. [34], suggest a response criteria of permanent set equal to the plate thickness for extreme loads on icebreakers using Jones' equation [29] developed from rigid-perfectly plastic analysis of a plate with fixed end conditions. For an infinitely long plate, the equation takes the form of that presented above in this section with C equal to .354 (curve 10 in Figure 22). Though curve 10 compares well with the finite element results of curves 8 and 9, the amounts of assumed permanent set are quite different. Curves 8 and 9 use 0.3 and 0.5 percent of the plate span which is approximately 3 to 16 percent of the plate thickness for the range of thicknesses considered. D'Olivera [35] states that Jones equation is conservative for stout plates and suggests using the ultimate stress or the average between the ultimate stress and the yield stress to give a more reasonable result. If Jones' equation is used with the ultimate stress (85,000 psi or 586 MPa) and permanent set equal to ten percent of the thickness, the result (the dashed line, curve 11, of Figure 22) falls within the finite element results of Chiu et al. Jones' equation has the advantage of being simpler to use in design studies since it is a straight-forward, explicit equation:

$$P/\sigma_c = 4\ (t/s)^2\ (1 + w/t)^2 \qquad w < t$$

where w is the amount of permanent set.

Appendix E presents a development of a plate response equation assuming pure membrane response with edge pull-in. The edge pull-in is resisted by springs equivalent in stiffness to the surrounding plating and permanent set of ten percent of the plate span is assumed (curve 12 of Figure 22). Appendix E shows that stout plates develop edge hinges at small amounts of permanent set using the work of Hughes. For the relatively large amount of permanent set assumed in curve 12, the plate will exhibit membrane behavior and edge pull-in will be resisted by the surrounding plate. This equation is compared in the figure to the case of pure membrane response with fixed end conditions and the same permanent set (curve 13) [30].

Figure 22 illustrates the wide range of reponse equations and criteria that could be applied to the icebreaker design problem. It does seem that with a better understanding of ice impact loads, a somewhat less conservative response criteria could be used resulting in substantial weight savings in the hull structure. There is a lack of test data however on stout plates which could be used to validate the various theories. Some data is presented by Chiu, et al. [30, 33]. The authors feel that additional test data on stout plates is required, however, to fully validate these methods.

Additionally, certain equations presented here are appropriate for small amounts of permanent set such as Hughes work and the finite element work of Chiu et al. Small permanent set (0.5 percent or less of the plate span) is the most appropriate response criteria for normal operating loads where permanent deflections are held to normal building fairness tolerances. Extreme or lifetime loads might be used with a much less conservative response criteria such as 10 percent of the plate span since there is still a great amount of load capacity in the plate before rupture. Jones' equation or those of Appendix E are intended to be used with larger amounts of permanent set.

6.2 Frame Response Criteria

While various amounts of permanent set have been considered for plating (lesser amounts for normal operating loads and greater amounts for extreme loads), framing should generally be designed elastically. When one considers plastic design of the plating, the assumption is that the edges of the plate do not deflect. Standard practice is to design framing to a maximum stress both in shear and bending which is determined by applying a factor of safety to both the yield stress in bending and the maximum shear stress at yield [36]. Some additional specific considerations are necessary for icebreakers. The heavily loaded hull plating and framing in icebreakers requires specific attention to a framing system that is forgiving (not prone to buckling such as a trussed support system) and resistant to local crippling failure of the frame webs and tripping of the frames. The latter requires the use of tripping brackets and aligning the frames perpendicular to the hull plating as much as the structural arrangement permits.

Framing tends to be governed by the shear loads, at least in high Arctic icebreakers. The frame span can then be determined by the bending moment after the frame depth as been determined by shear force requirements. As shown in Section 4, the highest average pressures on a frame quickly reach the force asymptote as the span of the frame is increased, indicating that a short frame carries essentially the same load as a longer one. Analytical methods such as a finite element analysis of a typical frame can refine the response predictions and therefore produce a more refined structure than is possible with simple beam theory.

It seems prudent to use the existing practice of elastic frame design with a factor of safety for normal operating loads. Extreme loads could be considered with smaller or no factor of safety or even small amounts of permanent set as long as the framing system can resist these loads in shear and bending without catastrophic collapse in some other mode of failure. It should be noted that the thick plating typically employed in icebreakers provides substantial increases in the plastic section modulus of frames over the elastic one unlike conventional ship structure. An excellent paper by Varsta [37] treats plastic response of an icebreaker frame and provides insight into design for other modes of failure besides shear and bending. Plastic design of framing can only be used with confidence after a better understanding of the strength of the combined system of framing and hull plating is developed. Finite element models of grillage systems for icebreakers may help in providing a better understanding of this problem.

7. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The data collection and analysis efforts of this study have, over the past five years, produced a solid data base of measured loads and procedure to use the data for design. Measured loads have been gathered in all operating areas of the Polar Class including thick level ice in the Antarctic and both first-year and multi-year ice in the Arctic (2039 recorded ice impact time-histories). This study was the first to produce detailed results of both the spatial and temporal variation of local ice impact pressures, and has greatly improved understanding of the ship/ice interaction process. Specific conclusions from the study are as follows:

- Both peak force and peak pressures during an impact increase with ice severity (ice thickness and ice strength).
- In the Arctic, operation at higher latitudes increases ice severity and therefore ice loads.
- Peak pressure during an impact appears to be only weakly dependent on impact speed, and no dependancy was discernable from the measured data.
- Peak force during an impact does increase with impact speed and a linear relationship between them appears reasonable.
- Total force increases with increasing contact area but average pressure decreases with increasing contact area. (6)
- The average pressure distribution on the hull within the impact zone at an instant in time is asymptotic to a line of constant force at large areas and to a line proportional to a negative fractional power of area (in the range of -0.2 to -0.3) at small areas. The latter asymptote appears related to the triaxial crushing strength versus strain rate dependancy of the ice.
- Extreme value distributions of ice force and pressure for the most severe ice conditions show Frechet type or upward curving distributions. Intermediate ice conditions follow a Gumbel or linear type distribution. Only the distributions for data recorded in light first-year ice conditions appear to be bounded or Weibul type distributions.
- It is possible to develop a design pressure versus area curve for local loads based on the extreme value distributions of the measured loads and an operational assessment of the ship's location. The design curve is best suited to ships similar in size and shape to the Polar Class, however, extension to ships of other sizes and shapes is possible using theoretical and empirical methods for scaling the loads.
- The statistical design approach is a rational one given the randomness of ice impact geometrics and ice properties.
- Two return period or load cases should be considered with the statistical design approach; a one to three year normal operating load and a lifetime survival load. The ship should resist the normal operating load with no deterioration in performance and resist survival loads with no catastrophic failure.

- Plastic plating response criteria should be considered to reduce hull weight given the high local loads. Small amounts of permanent set similar to the fabrication fairing criteria can be considered for normal operating loads while considerable amounts of permanent deformation can be considered for survival loads.

- Plastic design of frames in shear or bending should be considered very cautiously and only if all other failure mechanisms (tripping, web crippling, etc.) are carefully considered. Permanent set in frames is probably only acceptable for survival loads, and elastic design for normal operating loads is more prudent.

The authors feel that this study provides a good basis by documenting and providing understanding of local ice impact loads. It is recommended that, if additional research is done in this area, the focus of that work be directed toward gathering full-scale data on ships of other sizes and shapes and also collecting data at different areas other than the bow. A systematic test of load versus permanent set for small span to thickness plates would be useful in validating the various response therories appropriate to icebreakers. Finally, testing or analysis of thick plate grillage systems would provide insight to the amount of plastic deformation that can be considered in frame response.

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APPENDIX A

SUMMARY OF MEASURED DATA RANKED BY
SINGLE SUB-PANEL PRESSURE

KEY:

- PM1 - Maximum single sub-panel pressure (psi)
- PA1 - Average pressure over the contact area at the time of peak pressure (psi)
- A1 - Contact area at the time of peak pressure (sub-panels)
- F1 - Total panel force at the time of peak pressure (LT)
- PM2 - Maximum single sub-panel force (psi)
- PA2 - Average pressure over the contact area at the time of peak force (psi)
- A2 - Contact area at the time of peak force (sub-panels)
- F2 - Peak total panel force (LT)
- VEL - Ship velocity at impact (kts)

TABLE 1

SUMMARY OF DEPLOYMENTS, DATA SETS AND ICE CONDITIONS

TITLE & DATE	LOCATION	ICE TYPE	NO OF EVENTS
Beaufort Summer 82 Sep 28 - Oct 16	100-150 nm north of Prudhoe Bay in the Alaskan Beaufort Sea	MY	167
S Bering Winter 83 Mar 24 - Mar 26	Transit from St.Paul Is. to the west end of St.Lawrence Is. in the Bering Sea	FY	173
N Bering Winter 83 Mar 27 - Mar 28	Transit from St. Lawrence Is. to the Bering Strait in the Bering Sea	FY	241
S Chukchi Winter 83 Mar 29 -Apr 2 Apr 28 - May 2	Transit from the Bering Strait to Point Hope in the Chukchi Sea and return	FY,MY	299
N Chukchi Winter 83 Apr 3 - Apr 27	Round trip transit Point Hope to Wainwright in the Chukchi Sea, operation off Wainwright	FY,MY	513
Antarctic Summer 84 Jan 9 - Jan 13	McMurdo Sound, break-in to McMurdo Base	FY	309
Beaufort Summer 84 Nov 18 - Dec 1	Operation between Barter Is. and Barrow in the Beaufort Sea, transit through the Chukchi Sea to the Bering Strait	FY,MY	337
	SUBSETS OF KNOWN MULTIYEAR EVENTS		
N Chukchi Winter 83 MY Apr 3 - Apr 27	North Chukchi Sea off Wainwright	MY	67
Beaufort Summer 84 MY Nov 12 - Dec 1	Beaufort and Chukchi Seas	MY	32

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
03 OCT 1982	17:39:46	193	39	8	33	183	39	8	33	0.0
03 OCT 1982	20:44:43	195	72	6	45	163	81	6	51	0.0
03 OCT 1982	17:31:54	196	132	3	42	195	133	3	42	0.0
03 OCT 1982	17:32:24	196	132	3	42	195	132	3	42	0.0
02 OCT 1982	21:16:44	208	29	33	100	208	29	33	100	0.0
02 OCT 1982	22:02:36	208	28	45	132	174	33	46	159	0.0
03 OCT 1982	17:30:54	213	44	10	46	211	44	10	46	0.0
02 OCT 1982	21:37:51	226	65	12	82	156	26	28	82	0.0
02 OCT 1982	21:52:03	236	40	11	46	190	38	17	68	0.0
03 OCT 1982	20:47:29	242	242	1	25	242	55	5	29	0.0
02 OCT 1982	19:30:46	243	61	6	38	238	53	7	39	0.0
03 OCT 1982	20:20:16	245	31	11	36	237	116	4	49	0.0
02 OCT 1982	19:21:04	250	127	4	53	153	50	18	54	0.0
03 OCT 1982	22:24:38	250	51	13	70	250	51	13	70	0.0
03 OCT 1982	21:15:50	253	86	5	45	253	86	5	45	0.0
01 OCT 1982	11:46:07	260	119	4	50	260	119	4	50	0.0
03 OCT 1982	20:29:50	260	162	2	38	246	205	2	43	0.0
03 OCT 1982	20:45:42	266	83	11	96	266	83	11	95	0.0
03 OCT 1982	17:43:58	275	100	5	52	252	36	15	57	0.0
03 OCT 1982	22:27:24	292	292	1	31	292	292	1	31	0.0
01 OCT 1982	12:40:46	297	63	5	33	278	157	5	82	0.0
07 OCT 1982	17:52:51	298	74	11	85	269	72	13	98	0.0
03 OCT 1982	20:43:23	311	78	5	41	166	98	6	62	0.0
07 OCT 1982	17:56:57	316	96	10	101	291	98	11	113	0.0
04 OCT 1982	00:03:58	324	103	5	54	291	85	6	54	0.0
01 OCT 1982	12:37:52	326	139	4	58	326	139	4	58	0.0
02 OCT 1982	19:35:34	327	129	4	54	327	129	4	54	0.0
02 OCT 1982	19:50:48	327	245	4	103	325	46	31	150	0.0
01 OCT 1982	12:39:38	332	198	2	42	187	60	8	50	0.0
07 OCT 1982	17:56:27	333	104	4	44	237	65	8	55	0.0
03 OCT 1982	17:30:24	334	82	8	69	334	82	8	69	0.0
03 OCT 1982	20:45:12	350	148	4	62	350	148	4	62	0.0
03 OCT 1982	18:03:34	355	90	6	57	348	81	8	68	0.0
07 OCT 1982	18:07:53	358	323	2	68	358	323	2	68	0.0
02 OCT 1982	20:06:45	362	193	3	61	296	25	31	81	0.0
03 OCT 1982	18:03:04	364	55	10		301	49	21	108	0.0
03 OCT 1982	21:11:50	364	364	1	38	279	104	6	65	0.0
01 OCT 1982	21:17:53	366	22	54	125	312	23	53	128	0.0
03 OCT 1982	22:26:47	370	116	12	146	370	116	12	146	0.0
02 OCT 1982	19:44:01	371	48	20	101	320	56	19	112	0.0
02 OCT 1982	20:12:32	374	299	2	63	291	22	35	81	0.0
01 OCT 1982	11:50:06	375	278	2	58	365	293	2	61	0.0
01 OCT 1982	12:22:12	378	76	9	72	204	50	19	100	0.0
07 OCT 1982	17:52:21	378	63	10	66	298	81	10	85	0.0
01 OCT 1982	12:23:34	390	34	14	50	390	34	14	50	0.0
01 OCT 1982	21:23:29	392	50	43	226	377	53	42	234	0.0
02 OCT 1982	19:53:03	395	395	1	41	316	18	30	57	0.0
01 OCT 1982	12:20:26	404	72	7	53	274	97	10	102	0.0
07 OCT 1982	18:55:17	406	71	11	82	406	71	11	82	0.0
07 OCT 1982	13:55:46	419	102	7	75	371	106	7	78	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
01 OCT 1982	12:39:02	420	125	6	79	420	125	6	79	0.0
02 OCT 1982	18:38:34	421	64	10	67	408	80	8	67	0.0
03 OCT 1982	19:45:31	425	68	13	93	326	59	15	93	0.0
03 OCT 1982	22:25:18	425	135	10	142	421	136	10	143	0.0
03 OCT 1982	21:13:53	433	108	5	57	198	52	13	71	0.0
14 OCT 1982	11:59:00	434	118	9	111	419	102	11	118	0.0
07 OCT 1982	18:35:32	436	50	17	89	389	61	15	96	0.0
07 OCT 1982	18:29:22	437	77	11	89	437	77	11	89	0.0
02 OCT 1982	20:30:09	439	41	43	185	271	42	46	203	0.0
02 OCT 1982	20:25:04	440	76	11	88	339	45	22	104	0.0
02 OCT 1982	20:35:11	445	63	25	165	445	63	25	165	0.0
07 OCT 1982	18:29:51	448	226	4	95	448	226	4	95	0.0
13 OCT 1982	19:18:22	452	142	7	104	389	144	9	136	0.0
07 OCT 1982	18:07:24	452	120	14	176	452	120	14	176	0.0
02 OCT 1982	18:05:20	453	27	31	88	335	115	11	133	0.0
07 OCT 1982	18:19:14	455	48	16	81	280	71	15	112	0.0
01 OCT 1982	11:39:47	465	194	4	81	397	121	7	89	0.0
01 OCT 1982	12:22:39	472	106	20	222	407	102	21	225	0.0
03 OCT 1982	18:02:35	475	91	9	86	431	67	19	134	0.0
07 OCT 1982	17:55:57	475	63	9	59	288	156	4	65	0.0
14 OCT 1982	08:17:38	481	43	48	217	481	43	48	217	0.0
10 OCT 1982	23:14:38	482	100	16	168	437	102	16	171	0.0
12 OCT 1982	19:53:00	483	92	9	87	374	111	13	151	0.0
03 OCT 1982	19:42:32	494	69	14	101	494	69	14	101	0.0
13 OCT 1982	20:15:11	505	368	3	116	505	368	3	116	0.0
12 OCT 1982	19:09:51	510	100	7	73	510	100	7	73	0.0
07 OCT 1982	18:13:34	511	41	22	95	469	38	24	96	0.0
10 OCT 1982	18:24:24	514	190	5	100	342	90	12	113	0.0
14 OCT 1982	11:33:42	514	86	9	81	514	86	9	81	0.0
12 OCT 1982	16:41:49	516	114	10	120	516	114	10	120	0.0
14 OCT 1982	11:46:06	524	46	19	92	522	46	19	92	0.0
03 OCT 1982	20:31:59	525	93	11	107	436	140	11	162	0.0
12 OCT 1982	16:46:28	525	74	20	155	248	101	15	159	0.0
10 OCT 1982	15:58:18	535	91	8	76	360	63	12	79	0.0
01 OCT 1982	12:51:37	542	542	1	57	542	542	1	57	0.0
11 OCT 1982	00:19:37	544	194	9	183	475	242	8	203	0.0
03 OCT 1982	20:29:06	546	171	5	90	402	87	10	91	0.0
07 OCT 1982	18:28:52	546	124	8	104	239	75	17	134	0.0
03 OCT 1982	21:12:59	550	121	5	63	550	121	5	63	0.0
03 OCT 1982	20:47:00	551	77	34	275	550	83	33	297	0.0
02 OCT 1982	19:00:25	553	139	8	117	484	127	10	133	0.0
03 OCT 1982	21:10:32	557	93	13	127	397	89	14	131	0.0
12 OCT 1982	15:58:22	560	124	10	130	316	115	11	133	0.0
12 OCT 1982	16:41:20	563	94	14	138	444	122	12	154	0.0
10 OCT 1982	18:43:51	569	182	8	153	299	125	16	210	0.0
12 OCT 1982	17:16:31	573	96	17	171	500	94	21	207	0.0
14 OCT 1982	11:25:45	581	257	3	81	514	59	14	87	0.0
14 OCT 1982	13:30:39	582	134	7	135	505	218	7	160	0.0
12 OCT 1992	15:57:53	583	95	9	90	329	61	28	179	0.0
14 OCT 1982	14:01:50	583	94	13	128	378	113	15	187	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 OCT 1982	19:10:54	584	160	6	101	504	161	7	118	0.0
12 OCT 1982	20:05:43	584	58	23	140	562	53	38	211	0.0
13 OCT 1982	19:17:49	597	136	27	385	514	154	24	388	0.0
10 OCT 1982	16:37:38	600	66	14	97	432	80	15	126	0.0
10 OCT 1982	15:55:31	607	75	22	173	607	75	22	173	0.0
11 OCT 1982	00:25:34	610	156	7	115	574	165	8	155	0.0
13 OCT 1982	19:58:57	618	72	11	83	610	72	11	83	0.0
10 OCT 1982	16:46:14	630	130	13	177	630	130	13	177	0.0
13 OCT 1982	17:20:07	631	116	11	134	490	94	14	138	0.0
07 OCT 1982	19:39:56	633	181	6	114	633	181	6	114	0.0
14 OCT 1982	13:31:09	634	92	14	135	612	86	15	135	0.0
10 OCT 1982	15:56:01	635	129	7	95	475	142	7	104	0.0
01 OCT 1982	12:37:25	638	110	7	81	612	134	6	84	0.0
14 OCT 1982	08:31:00	638	27	50	142	541	63	48	317	0.0
13 OCT 1982	20:10:27	642	104	18	196	342	114	17	203	0.0
12 OCT 1982	14:51:47	645	288	3	91	503	67	21	148	0.0
08 OCT 1982	10:27:30	652	85	21	167	652	85	21	197	0.0
10 OCT 1982	17:05:13	655	79	19	157	655	79	19	157	0.0
02 OCT 1982	20:43:21	656	83	35	305	491	87	35	319	0.0
10 OCT 1982	16:38:45	658	198	7	145	658	198	7	145	0.0
01 OCT 1982	12:23:07	663	153	12	193	660	138	16	232	0.0
12 OCT 1982	14:39:52	678	120	12	151	656	116	13	158	0.0
14 OCT 1982	13:45:17	684	53	16	89	684	53	16	89	0.0
10 OCT 1982	17:05:42	687	158	6	99	687	158	6	99	0.0
11 OCT 1982	00:12:22	687	245	6	154	682	218	7	160	0.0
08 OCT 1982	09:00:44	696	472	2	99	333	49	24	123	0.0
03 OCT 1982	20:48:16	702	138	16	232	627	112	20	235	0.0
02 OCT 1982	17:51:42	714	115	8	97	714	115	8	97	0.0
07 OCT 1982	20:43:46	718	155	8	130	718	155	8	130	0.0
10 OCT 1982	23:20:04	726	124	12	156	699	114	14	157	0.0
14 OCT 1982	13:48:05	727	114	9	108	595	142	9	134	0.0
01 OCT 1982	12:05:27	733	94	14	138	689	128	11	148	0.0
10 OCT 1982	23:19:30	759	438	2	92	336	122	10	128	0.0
08 OCT 1982	07:43:40	763	172	11	198	597	79	35	290	0.0
12 OCT 1982	14:37:49	767	72	21	159	680	72	22	166	0.0
14 OCT 1982	12:46:54	782	95	28	279	712	101	27	286	0.0
07 OCT 1982	19:42:23	794	196	12	247	749	103	25	270	0.0
07 OCT 1982	23:02:29	808	125	11	144	451	155	13	211	0.0
08 OCT 1982	07:31:42	817	358	4	150	622	168	14	247	0.0
10 OCT 1982	16:34:26	818	248	5	130	670	385	4	162	0.0
14 OCT 1982	00:21:52	819	213	5	112	792	221	5	116	0.0
08 OCT 1982	00:35:10	873	175	8	147	757	188	8	158	0.0
08 OCT 1982	09:54:07	877	145	19	289	781	81	36	306	0.0
10 OCT 1982	17:56:27	878	124	10	130	878	124	10	130	0.0
12 OCT 1982	16:24:33	889	150	16	252	889	150	16	252	0.0
10 OCT 1982	15:23:02	901	45	32	151	295	57	42	251	0.0
07 OCT 1982	17:59:31	920	223	8	187	589	100	19	199	0.0
07 OCT 1982	18:26:30	923	67	29	204	923	67	29	204	0.0
01 OCT 1982	12:20:58	951	230	7		305	98	19	195	0.0
13 OCT 1982	19:57:54	950	163	9	154	947	133	11	159	0.0

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
10 OCT 1982	15:44:41	980	330	8	277	608	183	20	384	0.0
10 OCT 1982	16:36:14	1010	172	13	235	981	173	14	254	0.0
02 OCT 1982	20:10:03	1013	157	12	198	906	146	14	214	0.0
12 OCT 1982	18:58:17	1015	254	11	293	862	200	17	357	0.0
07 OCT 1982	18:00:00	1029	222	7	163	878	210	8	176	0.0
07 OCT 1982	18:48:11	1030	174	8	146	795	198	9	187	0.0
12 OCT 1982	17:07:44	1053	518	9	489	1053	518	9	489	0.0
10 OCT 1982	18:20:07	1093	308	7	226	1093	308	7	226	0.0
10 OCT 1982	18:41:16	1109	115	16	193	1109	115	16	193	0.0
13 OCT 1982	20:14:41	1115	195	10	206	776	201	11	232	0.0
88 NOV 1982	88:88:88	1140	306	5	161	917	357	4	167	0.0
14 OCT 1982	11:48:28	1156	212	11	245	752	207	20	434	0.0
14 OCT 1982	11:30:12	1206	136	15	214	1206	136	15	214	0.0
01 OCT 1982	12:21:26	1453	183	14	269	1366	175	15	275	0.0
10 OCT 1982	16:38:15	1464	335	12	422	1366	344	12	433	0.0
07 OCT 1982	23:30:29	1499	394	10	413	1499	394	10	413	0.0
14 OCT 1982	11:37:39	1617	295	16	495	1617	295	16	495	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
26 MAR 1983	11:57:53	26	10	15	22	15	5	45	22	0.0
26 MAR 1983	12:9:17	36	36	1	14	20	4	40	18	0.0
26 MAR 1983	11:56:47	37	16	3	15	21	5	43	21	0.0
26 MAR 1983	11:57:46	39	6	42	29	30	7	41	31	0.0
26 MAR 1983	12:4:28	40	4	35	14	26	9	15	25	0.0
26 MAR 1983	12:7:42	42	16	7	25	37	9	16	31	0.0
26 MAR 1983	11:58:35	43	30	3	26	41	9	38	36	0.0
26 MAR 1983	11:54:1	47	6	38	27	44	8	33	29	0.0
26 MAR 1983	12:2:26	49	10	8	22	49	10	8	22	0.0
26 MAR 1983	11:54:20	50	12	9	17	35	7	38	29	0.0
26 MAR 1983	11:54:12	51	27	2	15	28	5	48	23	0.0
26 MAR 1983	12:14:32	52	8	18	21	44	7	33	24	0.0
26 MAR 1983	11:55:1	54	8	47	38	42	9	46	44	0.0
26 MAR 1983	11:54:30	62	7	41	32	43	8	49	43	0.0
26 MAR 1983	11:53:56	68	13	8	17	47	11	9	19	0.0
26 MAR 1983	19:31:44	113	21	21	69	90	17	33	69	0.0
26 MAR 1983	19:51:23	117	18	48	98	92	20	48	101	0.0
26 MAR 1983	19:51:7	121	21	45	101	105	24	47	118	0.0
26 MAR 1983	19:46:13	123	25	45	118	123	25	45	118	0.0
26 MAR 1983	19:0:10	135	22	48	111	92	23	49	117	0.0
26 MAR 1983	20:32:26	135	25	47	125	89	26	50	138	0.0
26 MAR 1983	18:59:43	137	49	4	35	126	59	3	43	0.0
26 MAR 1983	19:45:14	137	17	53	93	92	18	50	94	0.0
26 MAR 1983	19:45:52	139	19	46	90	86	21	43	96	0.0
26 MAR 1983	19:9:27	140	15	22	42	89	18	10	48	0.0
26 MAR 1983	18:55:39	141	74	5	57	141	60	10	81	0.0
26 MAR 1983	19:51:17	141	18	45	87	89	31	12	93	0.0
26 MAR 1983	20:32:43	143	19	52	104	143	19	52	104	0.0
26 MAR 1983	18:46:6	144	17	12	29	82	14	21	36	0.0
26 MAR 1983	19:45:5	145	17	44	79	92	19	48	96	0.0
26 MAR 1983	19:10:12	148	27	10	43	77	19	27	64	0.0
26 MAR 1983	19:40:1	149	18	41	78	102	18	46	86	0.0
26 MAR 1983	19:51:1	149	16	45	74	100	22	46	106	0.0
26 MAR 1983	10:11:17	152	20	20	49	99	21	20	52	0.0
26 MAR 1983	19:50:24	152	22	46	106	92	24	45	114	0.0
26 MAR 1983	19:45:27	153	17	51	90	92	17	51	90	0.0
26 MAR 1983	18:39:23	154	44	8	59	154	44	8	59	0.0
26 MAR 1983	18:47:53	154	30	43	139	94	35	44	166	0.0
26 MAR 1983	19:46:39	154	20	39	93	154	20	39	93	0.0
26 MAR 1983	19:50:55	154	22	44	104	154	22	44	104	0.0
26 MAR 1983	19:51:29	154	53	7	127	154	53	7	127	0.0
26 MAR 1983	1:42:29	157	18	59	114	109	22	55	129	0.0
26 MAR 1983	18:59:57	157	19	27	58	115	18	30	61	0.0
26 MAR 1983	19:10:1	157	27	18	59	118	28	29	91	0.0
26 MAR 1983	3:3:34	160	17	56	98	65	18	59	110	0.0
26 MAR 1983	2:55:43	161	20	58	120	92	24	59	146	0.0
26 MAR 1983	18:45:51	161	18	12	50	161	18	12	50	0.0
26 MAR 1983	19:46:7	162	15	48	77	92	18	47	92	0.0
26 MAR 1983	19:51:42	163	20	49	101	163	20	49	101	0.0
26 MAR 1983	18:59:25	164	47	4	37	124	30	10	43	0.0

SOUTH BERING WINTER 1983

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
26 MAR 1983	19:15:26	164	164	1	38	88	19	10	42	0.0
26 MAR 1983	19:52:13	164	18	46	87	162	36	13	88	0.0
26 MAR 1983	10:17:33	165	33	6	35	152	99	2	36	0.0
25 MAR 1983	23:6:3	166	15	51	82	123	22	50	117	0.0
26 MAR 1983	10:18:5	166	14	42	60	146	23	30	75	0.0
25 MAR 1983	17:12:0	167	35	12	52	162	39	11	55	0.0
25 MAR 1983	23:29:14	167	15	51	78	167	15	51	78	0.0
26 MAR 1983	19:39:47	169	15	46	72	103	21	46	100	0.0
26 MAR 1983	18:39:28	170	23	16	44	90	39	8	50	0.0
26 MAR 1983	10:18:17	172	24	39	98	172	24	39	98	0.0
25 MAR 1983	19:45:46	172	18	48	92	112	22	49	115	0.0
26 MAR 1983	3:20:9	174	19	59	120	174	19	59	120	0.0
26 MAR 1983	19:51:36	174	18	45	87	93	26	43	117	0.0
26 MAR 1983	18:55:45	176	60	3	42	76	22	14	50	0.0
26 MAR 1983	19:49:33	176	25	46	121	168	26	45	122	0.0
26 MAR 1983	0:44:7	177	16	56	93	138	16	56	95	0.0
26 MAR 1983	0:48:47	177	17	56	102	130	24	53	134	0.0
25 MAR 1983	23:4:59	179	18	53	102	148	27	49	138	0.0
26 MAR 1983	10:18:25	179	19	38	81	156	23	37	89	0.0
26 MAR 1983	2:53:3	180	32	54	184	175	32	56	186	0.0
25 MAR 1983	22:57:37	181	22	52	119	155	23	52	127	0.0
26 MAR 1983	2:58:38	182	19	58	115	182	19	58	115	0.0
25 MAR 1983	22:17:58	183	19	52	101	146	32	46	155	0.0
26 MAR 1983	18:55:29	183	53	7	48	147	82	5	56	0.0
26 MAR 1983	0:54:33	184	33	50	172	184	33	50	172	0.0
26 MAR 1983	10:1:12	184	39	7	45	121	15	13	47	0.0
26 MAR 1983	10:4:48	184	32	20	77	142	24	32	86	0.0
25 MAR 1983	21:40:48	185	13	54	73	161	161	1	130	0.0
25 MAR 1983	22:57:18	187	21	52	117	187	21	52	117	0.0
26 MAR 1983	2:44:25	187	27	58	165	175	30	57	177	0.0
26 MAR 1983	10:11:37	187	29	11	48	84	15	36	62	0.0
26 MAR 1983	19:49:39	188	24	46	118	172	25	49	127	0.0
25 MAR 1983	23:5:48	191	19	55	107	165	32	49	162	0.0
25 MAR 1983	23:3:27	193	20	55	115	143	29	48	146	0.0
26 MAR 1983	19:49:27	193	19	31	89	156	31	26	111	0.0
26 MAR 1983	2:54:5	194	17	57	100	136	19	55	110	0.0
25 MAR 1983	22:29:22	197	12	57	69	197	12	57	69	0.0
26 MAR 1983	0:54:54	197	18	59	112	150	22	55	124	0.0
25 MAR 1983	22:11:18	198	21	49	110	135	28	40	128	0.0
26 MAR 1983	0:57:44	198	19	55	110	182	21	54	117	0.0
26 MAR 1983	19:45:41	198	21	41	108	117	22	51	121	0.0
25 MAR 1983	16:54:6	199	40	12	67	128	26	37	106	0.0
26 MAR 1983	0:54:25	200	33	51	177	193	34	50	179	0.0
25 MAR 1983	23:11:57	201	25	56	144	150	29	50	154	0.0
25 MAR 1983	22:29:7	202	21	53	115	162	21	54	116	0.0
26 MAR 1983	1:8:43	202	24	58	146	189	29	55	165	0.0
26 MAR 1983	2:49:27	203	28	58	172	177	32	57	194	0.0
26 MAR 1983	2:54:49	203	18	57	110	202	19	57	112	0.0
26 MAR 1983	2:43:56	204	17	57	103	96	19	56	113	0.0
25 MAR 1983	23:3:51	205	19	52	106	197	25	52	136	0.0

SOUTH BERING WINTER 1983

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
25 MAR 1983	22:2:42	206	18	51	95	100	18	54	103	0.0
25 MAR 1983	21:49:12	207	50	7	55	123	30	27	97	0.0
26 MAR 1983	2:50:59	207	22	58	136	191	25	56	146	0.0
26 MAR 1983	19:49:12	207	17	46	83	143	22	46	107	0.0
25 MAR 1983	17:11:55	209	17	35	66	113	18	36	69	0.0
25 MAR 1983	22:48:20	210	30	45	141	210	30	45	141	0.0
25 MAR 1983	22:56:57	211	12	55	69	135	15	52	82	0.0
26 MAR 1983	2:51:22	211	19	58	116	211	19	58	116	0.0
25 MAR 1983	10:14:58	211	16	38	65	157	21	29	70	0.0
25 MAR 1983	22:48:31	214	17	49	89	99	22	45	106	0.0
26 MAR 1983	10:12:43	214	14	44	65	201	15	43	68	0.0
25 MAR 1983	22:18:26	216	19	53	112	194	20	52	114	0.0
26 MAR 1983	1:5:42	216	25	56	146	175	25	56	149	0.0
26 MAR 1983	10:8:46	216	115	2	33	99	52	8	53	0.0
25 MAR 1983	17:17:33	220	56	5	47	220	56	5	47	0.0
26 MAR 1983	1:16:2	220	18	57	110	146	20	60	128	0.0
26 MAR 1983	18:38:58	220	28	42	125	186	40	31	141	0.0
26 MAR 1983	18:55:24	222	34	9	45	126	30	10	46	0.0
26 MAR 1983	10:4:27	223	61	4	46	106	27	17	60	0.0
25 MAR 1983	22:18:17	226	23	49	119	216	26	48	128	0.0
25 MAR 1983	21:50:1	228	27	51	147	228	29	50	153	0.0
26 MAR 1983	10:8:57	228	15	26	45	146	87	4	68	0.0
26 MAR 1983	2:52:25	229	18	57	108	222	18	56	108	0.0
26 MAR 1983	2:53:38	231	19	57	113	178	20	56	115	0.0
26 MAR 1983	10:13:56	231	37	21	91	231	37	21	91	0.0
25 MAR 1983	22:57:24	234	15	53	86	234	15	53	86	0.0
26 MAR 1983	10:12:17	234	34	40	145	198	37	37	146	0.0
25 MAR 1983	22:11:30	238	26	50	137	155	29	51	156	0.0
26 MAR 1983	6:10:4	241	76	5	63	171	25	21	70	0.0
25 MAR 1983	23:11:51	249	38	53	211	242	39	52	212	0.0
25 MAR 1983	17:40:59	250	52	8	69	91	15	53	81	0.0
26 MAR 1983	2:43:31	250	49	48	247	250	49	48	247	0.0
26 MAR 1983	5:31:41	250	44	13	65	167	40	17	76	0.0
25 MAR 1983	23:5:25	252	24	51	130	191	24	51	130	0.0
26 MAR 1983	5:5:24	252	33	28	107	163	37	27	116	0.0
25 MAR 1983	22:29:31	261	32	52	173	255	31	53	174	0.0
26 MAR 1983	3:11:30	261	28	58	173	261	28	58	173	0.0
25 MAR 1983	23:4:54	262	21	54	117	174	39	43	180	0.0
26 MAR 1983	2:51:52	263	19	57	111	263	19	57	111	0.0
26 MAR 1983	2:51:17	268	22	57	134	133	23	58	141	0.0
26 MAR 1983	2:49:0	270	20	58	121	184	22	55	126	0.0
26 MAR 1983	19:59:22	272	23	53	126	272	23	53	126	0.0
26 MAR 1983	19:11:29	277	24	35	89	138	24	37	96	0.0
25 MAR 1983	22:10:51	279	17	53	95	267	16	56	97	0.0
26 MAR 1983	19:45:21	280	20	49	103	96	19	53	105	0.0
25 MAR 1983	20:42:30	288	22	44	103	282	31	40	130	0.0
25 MAR 1983	22:28:53	299	16	55	90	186	21	56	121	0.0
26 MAR 1983	3:7:50	289	24	56	133	221	31	58	129	0.0
25 MAR 1983	17:41:32	291	27	45	129	249	32	36	131	0.0
26 MAR 1983	2:46:24	292	20	58	123	292	20	58	123	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
26 MAR 1983	2:44:8	294	22	58	135	250	24	59	147	0.0
26 MAR 1983	2:45:54	295	24	59	146	250	29	57	171	0.0
26 MAR 1983	2:43:36	296	43	48	217	208	39	57	233	0.0
26 MAR 1983	3:8:9	296	26	54	146	296	26	54	146	0.0
26 MAR 1983	19:44:39	303	20	45	97	239	28	46	138	0.0
26 MAR 1983	10:17:25	304	27	26	82	217	28	44	133	0.0
26 MAR 1983	0:48:39	312	24	53	132	125	24	56	142	0.0
26 MAR 1983	19:39:42	327	20	41	92	319	44	22	117	0.0
26 MAR 1983	10:4:32	335	63	20	141	160	42	29	143	0.0
26 MAR 1983	1:55:8	336	31	58	188	336	31	58	188	0.0
26 MAR 1983	19:10:40	337	37	17	94	337	37	17	94	0.0
26 MAR 1983	6:18:39	345	35	31	121	325	38	35	141	0.0
26 MAR 1983	2:56:53	350	25	58	153	350	25	58	153	0.0
26 MAR 1983	19:51:12	356	32	29	113	198	25	42	115	0.0
25 MAR 1983	5:7:53	363	21	22	50	363	21	22	50	0.0
26 MAR 1983	10:1:38	367	87	5	53	189	120	4	59	0.0
25 MAR 1983	22:2:30	369	19	48	95	182	18	55	103	0.0
26 MAR 1983	6:9:51	374	37	22	93	374	37	22	93	0.0
26 MAR 1983	3:19:43	385	24	58	144	385	24	58	144	0.0
25 MAR 1983	23:29:5	409	28	50	148	327	29	52	161	0.0
26 MAR 1983	6:26:9	431	41	23	145	431	41	23	145	0.0
25 MAR 1983	21:49:3	483	42	49	216	281	45	50	236	0.0
25 MAR 1983	2:52:14	1137	47	51	253	717	49	54	280	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
27 MAR 1983	7:39:39	114	19	59	118	114	19	59	118	0.0
27 MAR 1983	7:32:22	124	29	7	63	39	15	41	69	0.0
27 MAR 1983	7:34:44	152	20	58	119	83	20	58	121	0.0
27 MAR 1983	7:34:53	156	19	57	111	96	19	57	113	0.0
27 MAR 1983	7:19:13	160	20	55	115	113	22	52	121	0.0
27 MAR 1983	7:39:54	162	21	48	103	114	20	54	112	0.0
27 MAR 1983	7:39:34	165	21	59	133	125	23	57	136	0.0
27 MAR 1983	15:15:45	165	85	8	79	164	83	8	82	0.0
27 MAR 1983	7:23:34	168	20	58	119	132	21	55	121	0.0
27 MAR 1983	6:59:50	170	19	35	81	137	114	3	93	0.0
27 MAR 1983	6:59:36	175	16	54	88	173	16	53	89	0.0
27 MAR 1983	15:6:50	179	111	2	27	169	125	2	30	0.0
27 MAR 1983	14:49:33	190	100	3	41	162	102	3	44	0.0
27 MAR 1983	14:54:7	191	24	11	39	108	26	11	40	0.0
27 MAR 1983	7:28:23	192	31	55	177	183	39	49	204	0.0
27 MAR 1983	14:54:0	196	47	6	45	147	39	8	47	0.0
26 MAR 1983	23:22:7	198	18	39	94	122	31	45	155	0.0
27 MAR 1983	1:3:33	200	20	57	120	193	39	46	197	0.0
27 MAR 1983	15:13:54	200	81	7	63	200	81	7	63	0.0
27 MAR 1983	7:14:58	203	21	57	128	203	21	57	128	0.0
27 MAR 1983	7:3:7	204	16	50	86	102	17	49	95	0.0
27 MAR 1983	6:24:41	207	20	59	126	158	26	55	149	0.0
27 MAR 1983	14:35:46	209	28	41	121	209	28	41	121	0.0
27 MAR 1983	1:24:37	211	23	55	131	191	23	53	133	0.0
27 MAR 1983	7:3:15	216	24	55	136	135	26	52	143	0.0
27 MAR 1983	0:19:38	218	20	48	100	218	20	48	100	0.0
27 MAR 1983	0:46:28	220	21	54	119	186	25	51	133	0.0
27 MAR 1983	0:1:25	222	23	49	123	149	31	42	143	0.0
27 MAR 1983	22:51:34	229	78	7	69	229	78	7	69	0.0
27 MAR 1983	0:19:32	231	41	49	209	231	41	49	209	0.0
27 MAR 1983	7:24:5	232	27	56	157	232	27	56	157	0.0
27 MAR 1983	14:47:52	236	43	9	63	136	86	5	71	0.0
27 MAR 1983	21:9:48	236	54	5	54	164	41	10	70	0.0
27 MAR 1983	21:53:51	236	25	23	63	123	22	26	64	0.0
27 MAR 1983	15:15:33	238	46	16	81	157	67	18	131	0.0
27 MAR 1983	15:58:4	239	82	8	77	222	95	8	90	0.0
27 MAR 1983	15:16:50	245	101	10	113	196	105	10	117	0.0
27 MAR 1983	21:10:9	245	46	16	83	237	50	19	102	0.0
27 MAR 1983	0:56:38	246	21	54	121	184	49	46	238	0.0
27 MAR 1983	15:53:36	247	87	10	93	247	87	10	93	0.0
27 MAR 1983	0:8:0	249	20	49	102	249	20	49	102	0.0
27 MAR 1983	15:6:0	252	49	7	43	189	107	4	60	0.0
27 MAR 1983	13:38:22	253	50	6	46	194	38	8	47	0.0
28 MAR 1983	14:4:27	253	49	14	80	253	49	14	80	0.0
27 MAR 1983	15:16:13	254	55	21	140	254	55	21	140	0.0
27 MAR 1983	0:48:29	257	26	52	141	204	42	49	214	0.0
27 MAR 1983	15:14:40	259	66	11	83	259	66	11	83	0.0
27 MAR 1983	21:45:29	262	114	4	91	201	90	9	127	0.0
27 MAR 1983	0:48:4	265	25	52	134	265	25	52	134	0.0
27 MAR 1983	18:52:38	265	66	8	58	161	41	16	74	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 MAR 1983	0:13:41	265	24	50	130	155	27	46	136	0.0
27 MAR 1983	15:7:16	266	83	6	60	266	83	6	60	0.0
28 MAR 1983	0:7:28	266	75	8	100	264	53	13	108	0.0
28 MAR 1983	14:3:33	267	68	17	129	267	68	17	129	0.0
27 MAR 1983	15:29:0	268	81	18	156	221	70	22	165	0.0
27 MAR 1983	7:28:29	269	42	51	222	236	42	51	227	0.0
27 MAR 1983	22:27:42	269	31	32	107	178	36	33	125	0.0
28 MAR 1983	0:32:36	269	25	56	148	184	39	54	223	0.0
27 MAR 1983	15:13:40	271	92	5	50	271	92	5	50	0.0
28 MAR 1983	21:1:48	271	67	11	80	271	67	11	80	0.0
27 MAR 1983	0:14:56	272	15	40	63	203	27	42	120	0.0
27 MAR 1983	0:48:12	272	25	53	143	205	31	54	175	0.0
27 MAR 1983	18:22:56	273	44	8	43	251	62	17	123	0.0
28 MAR 1983	22:17:0	274	157	4	81	274	157	4	81	0.0
27 MAR 1983	17:20:54	275	66	5	42	187	46	9	48	0.0
27 MAR 1983	15:29:15	276	212	2	49	188	127	4	62	0.0
27 MAR 1983	22:10:8	276	56	22	157	255	69	16	170	0.0
28 MAR 1983	0:6:39	276	126	3	76	234	82	5	79	0.0
28 MAR 1983	21:36:56	277	88	4	42	72	20	21	55	0.0
28 MAR 1983	0:20:27	278	29	48	153	278	29	48	153	0.0
27 MAR 1983	15:12:26	279	106	11	137	279	106	11	137	0.0
27 MAR 1983	17:30:21	279	108	13	152	279	108	13	152	0.0
27 MAR 1983	23:22:33	279	18	37	84	137	22	45	109	0.0
28 MAR 1983	13:50:7	279	30	33	117	279	30	33	117	0.0
28 MAR 1983	0:12:26	280	24	52	131	280	24	52	131	0.0
27 MAR 1983	0:55:22	281	25	57	147	226	45	51	242	0.0
28 MAR 1983	0:25:59	281	22	53	125	119	25	55	145	0.0
27 MAR 1983	15:13:23	282	57	7	44	282	57	7	44	0.0
27 MAR 1983	21:59:30	282	77	4	50	147	26	10	57	0.0
27 MAR 1983	17:43:16	283	151	4	71	283	151	4	71	0.0
28 MAR 1983	0:34:8	283	26	54	145	126	28	56	162	0.0
27 MAR 1983	1:24:46	284	27	51	142	249	30	48	153	0.0
27 MAR 1983	16:55:49	284	40	14	71	113	36	21	84	0.0
28 MAR 1983	11:50:54	284	31	25	86	284	31	25	86	0.0
27 MAR 1983	21:51:7	285	37	16	67	281	46	17	90	0.0
28 MAR 1983	13:26:0	285	31	41	131	285	31	41	131	0.0
27 MAR 1983	15:12:50	286	106	5	64	200	51	13	78	0.0
28 MAR 1983	7:45:55	286	21	50	108	195	23	49	121	0.0
28 MAR 1983	7:56:46	287	38	52	208	287	41	49	210	0.0
27 MAR 1983	21:49:35	288	36	24	97	288	36	24	97	0.0
28 MAR 1983	0:13:30	289	24	44	118	289	24	44	118	0.0
28 MAR 1983	0:14:45	291	30	48	158	269	30	49	159	0.0
28 MAR 1983	0:48:11	291	32	55	187	208	34	54	193	0.0
28 MAR 1983	14:2:54	291	40	13	57	126	64	10	75	0.0
28 MAR 1983	0:27:17	292	26	54	145	208	26	53	146	0.0
27 MAR 1983	17:3:40	293	59	9	61	186	64	6	65	0.0
27 MAR 1983	18:26:2	293	82	4	44	145	31	18	61	0.0
27 MAR 1983	18:37:29	293	71	10	78	154	76	10	85	0.0
28 MAR 1983	11:46:9	294	35	20	79	182	35	25	102	0.0
27 MAR 1983	0:1:6	296	29	51	162	205	32	46	167	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
27 MAR 1983	15:11:58	296	51	15	84	285	55	19	116	0.0
28 MAR 1983	0:39:30	296	25	54	143	296	25	54	143	0.0
27 MAR 1983	1:3:43	297	25	57	149	297	25	57	149	0.0
27 MAR 1983	0:45:31	298	35	47	172	230	33	49	173	0.0
28 MAR 1983	22:14:9	300	109	4	82	115	27	30	92	0.0
27 MAR 1983	15:12:8	301	77	5	49	209	91	8	90	0.0
27 MAR 1983	21:29:35	301	132	3	47	260	199	2	48	0.0
28 MAR 1983	21:36:50	301	128	4	61	91	26	32	91	0.0
27 MAR 1983	7:28:34	306	32	57	191	237	44	51	241	0.0
27 MAR 1983	15:6:5	306	119	3	40	185	97	5	53	0.0
28 MAR 1983	7:46:28	306	34	35	123	232	35	38	145	0.0
28 MAR 1983	13:13:9	310	39	50	206	268	39	51	208	0.0
27 MAR 1983	15:12:14	311	220	2	65	182	67	8	74	0.0
28 MAR 1983	17:22:27	312	51	8	68	312	51	8	68	0.0
28 MAR 1983	17:27:52	313	55	12	80	233	21	35	82	0.0
27 MAR 1983	18:51:39	314	41	16	72	314	41	16	72	0.0
28 MAR 1983	8:13:24	314	109	4	51	219	196	3	70	0.0
27 MAR 1983	14:47:46	315	19	44	86	315	19	44	86	0.0
28 MAR 1983	17:44:47	315	69	12	108	219	40	26	113	0.0
28 MAR 1983	22:13:3	318	20	39	80	124	40	19	87	0.0
27 MAR 1983	23:9:24	319	37	50	195	319	37	50	195	0.0
28 MAR 1983	22:13:54	320	23	30	75	257	47	12	77	0.0
27 MAR 1983	21:30:19	321	46	27	156	321	46	27	156	0.0
27 MAR 1983	22:29:27	322	101	4	85	322	101	4	85	0.0
27 MAR 1983	21:44:16	323	37	49	191	323	37	49	191	0.0
28 MAR 1983	8:57:41	323	33	27	97	323	33	27	97	0.0
27 MAR 1983	7:2:57	324	21	56	124	324	21	56	124	0.0
27 MAR 1983	22:17:11	326	36	17	72	180	30	21	74	0.0
28 MAR 1983	0:14:15	326	35	48	182	227	39	46	192	0.0
28 MAR 1983	13:13:0	326	42	45	197	248	39	50	205	0.0
28 MAR 1983	13:25:3	329	29	35	108	329	29	35	108	0.0
28 MAR 1983	13:55:0	331	122	3	45	223	48	10	83	0.0
28 MAR 1983	17:44:52	333	55	19	118	316	68	16	129	0.0
28 MAR 1983	8:53:16	334	52	11	61	124	24	26	66	0.0
27 MAR 1983	17:44:44	335	27	30	90	136	26	37	109	0.0
28 MAR 1983	0:13:52	338	43	43	198	338	43	43	198	0.0
28 MAR 1983	17:57:9	339	61	8	58	219	38	23	96	0.0
27 MAR 1983	18:21:41	340	46	14	76	172	147	3	89	0.0
27 MAR 1983	21:6:51	340	176	2	49	327	327	1	53	0.0
27 MAR 1983	22:19:23	340	93	8	91	338	73	13	113	0.0
28 MAR 1983	13:34:30	340	27	40	114	277	30	38	120	0.0
27 MAR 1983	22:18:26	344	48	10	54	209	55	9	60	0.0
27 MAR 1983	20:33:41	345	44	19	90	156	40	22	94	0.0
28 MAR 1983	19:7:5	347	24	33	89	347	24	33	89	0.0
28 MAR 1983	17:39:18	348	48	15	95	321	93	8	100	0.0
27 MAR 1983	20:16:20	352	22	26	64	166	59	9	78	0.0
28 MAR 1983	8:57:51	353	54	9	55	353	54	9	65	0.0
27 MAR 1983	17:7:26	354	57	24	148	254	74	23	184	0.0
28 MAR 1983	0:39:4	355	146	3	143	161	26	58	159	0.0
29 MAR 1983	13:12:9	355	38	50	199	291	42	43	210	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 MAR 1983	0:14:50	356	58	12	128	338	27	46	128	0.0
27 MAR 1983	0:46:21	358	34	47	176	358	34	47	176	0.0
27 MAR 1983	7:6:51	360	37	55	212	324	37	55	214	0.0
28 MAR 1983	22:8:56	360	32	26	96	360	32	26	96	0.0
27 MAR 1983	21:46:6	361	52	11	69	229	44	21	108	0.0
28 MAR 1983	13:52:26	361	60	9	78	361	60	9	78	0.0
27 MAR 1983	22:54:25	362	98	9	113	239	94	10	119	0.0
27 MAR 1983	1:3:12	363	37	54	211	226	45	55	257	0.0
27 MAR 1983	21:10:3	363	202	2	54	125	45	12	61	0.0
28 MAR 1983	17:25:39	363	78	8	116	363	78	8	116	0.0
27 MAR 1983	21:54:11	367	51	20	177	348	63	30	207	0.0
27 MAR 1983	22:26:0	367	39	17	104	367	39	17	104	0.0
28 MAR 1983	0:32:23	368	38	55	220	247	42	53	231	0.0
27 MAR 1983	18:29:27	369	120	7	116	369	120	7	116	0.0
27 MAR 1983	20:28:42	369	33	40	138	369	33	40	138	0.0
27 MAR 1983	23:21:35	369	27	31	100	369	27	31	100	0.0
27 MAR 1983	1:4:1	370	24	54	136	370	24	54	136	0.0
28 MAR 1983	14:3:5	370	104	8	97	370	104	8	97	0.0
26 MAR 1983	23:22:16	372	26	34	116	159	48	21	121	0.0
28 MAR 1983	13:56:30	373	71	12	93	327	67	12	100	0.0
27 MAR 1983	21:16:34	374	53	16	92	374	53	16	92	0.0
27 MAR 1983	22:28:16	374	96	5	75	372	129	5	97	0.0
27 MAR 1983	20:31:48	375	82	13	121	293	77	14	122	0.0
28 MAR 1983	22:16:15	375	23	36	94	375	23	36	94	0.0
27 MAR 1983	15:53:0	378	40	27	115	357	56	20	121	0.0
27 MAR 1983	0:49:18	379	23	55	130	182	25	55	142	0.0
27 MAR 1983	7:44:9	379	25	58	155	379	25	58	155	0.0
28 MAR 1983	0:23:14	380	22	51	120	113	27	59	168	0.0
28 MAR 1983	13:54:6	380	178	3	59	380	178	3	59	0.0
27 MAR 1983	15:13:31	381	80	12	106	275	77	13	108	0.0
28 MAR 1983	14:5:11	384	54	19	117	384	54	19	117	0.0
28 MAR 1983	13:15:53	385	22	40	95	298	24	40	100	0.0
27 MAR 1983	1:3:51	387	36	50	186	312	40	47	199	0.0
28 MAR 1983	22:8:41	387	25	32	86	307	30	33	107	0.0
27 MAR 1983	21:17:49	394	50	26	148	191	53	26	156	0.0
28 MAR 1983	22:13:20	396	25	41	109	257	31	40	130	0.0
28 MAR 1983	8:42:42	398	45	13	67	367	99	5	68	0.0
28 MAR 1983	0:22:2	400	51	48	262	283	56	47	292	0.0
28 MAR 1983	17:42:19	400	41	19	98	363	37	21	99	0.0
28 MAR 1983	14:4:4	403	80	13	114	403	80	13	114	0.0
27 MAR 1983	18:18:8	404	71	13	146	252	79	17	150	0.0
27 MAR 1983	17:21:1	407	96	6	64	211	74	8	75	0.0
28 MAR 1983	17:38:41	408	31	36	125	396	40	33	148	0.0
28 MAR 1983	22:18:36	409	87	10	152	287	113	8	156	0.0
27 MAR 1983	21:49:45	410	91	10	107	410	91	10	107	0.0
27 MAR 1983	17:28:34	413	413	1	59	282	125	10	147	0.0
27 MAR 1983	21:48:48	416	21	35	81	185	30	36	113	0.0
29 MAR 1983	11:49:39	416	36	29	120	416	36	29	120	0.0
28 MAR 1983	17:52:57	415	47	17	99	258	29	35	106	0.0
28 MAR 1983	13:16:34	422	24	51	123	187	36	47	180	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 MAR 1983	0:38:58	423	30	54	173	423	30	54	173	0.0
27 MAR 1983	23:6:26	424	41	48	206	424	41	48	206	0.0
27 MAR 1983	7:28:41	425	39	50	207	408	46	51	245	0.0
28 MAR 1983	13:23:7	425	42	46	204	361	43	50	227	0.0
28 MAR 1983	22:17:28	426	54	15	97	426	54	15	97	0.0
27 MAR 1983	17:14:20	427	70	7	63	240	75	7	66	0.0
28 MAR 1983	0:31:11	428	34	53	192	428	34	53	192	0.0
28 MAR 1983	13:16:47	429	21	45	101	429	21	45	101	0.0
27 MAR 1983	15:16:19	430	58	19	125	396	62	24	165	0.0
28 MAR 1983	19:47:25	430	52	47	256	430	52	47	256	0.0
28 MAR 1983	7:45:47	441	36	44	168	322	33	53	186	0.0
27 MAR 1983	21:40:47	443	56	23	191	443	56	23	191	0.0
27 MAR 1983	17:45:33	446	33	52	181	446	33	52	181	0.0
28 MAR 1983	13:27:3	452	30	46	144	452	30	46	144	0.0
27 MAR 1983	14:59:37	453	45	34	162	453	45	34	162	0.0
28 MAR 1983	18:5:38	459	38	34	140	387	57	22	148	0.0
27 MAR 1983	16:0:0	462	146	4	80	413	306	2	87	0.0
27 MAR 1983	17:7:4	472	62	13	96	154	74	16	130	0.0
28 MAR 1983	0:26:21	473	37	51	198	473	37	51	198	0.0
28 MAR 1983	19:9:5	475	43	26	127	211	60	23	162	0.0
28 MAR 1983	0:9:27	478	29	55	168	478	29	55	168	0.0
27 MAR 1983	17:4:19	484	80	12	166	484	80	12	166	0.0
27 MAR 1983	15:12:32	490	96	13	147	431	87	26	245	0.0
27 MAR 1983	0:48:42	491	31	52	168	368	36	49	198	0.0
28 MAR 1983	13:55:50	506	77	12	101	481	116	8	105	0.0
27 MAR 1983	7:28:7	507	32	56	189	474	32	58	196	0.0
28 MAR 1983	17:26:23	507	26	45	121	262	32	44	146	0.0
27 MAR 1983	20:25:39	508	144	9	145	508	144	9	145	0.0
27 MAR 1983	17:26:51	516	123	5	78	196	180	3	80	0.0
27 MAR 1983	17:26:29	535	109	31	359	535	109	31	359	0.0
27 MAR 1983	20:58:3	537	64	10	75	123	36	19	79	0.0
28 MAR 1983	11:53:33	550	38	40	162	461	84	17	167	0.0
28 MAR 1983	0:26:30	557	54	53	303	414	68	50	357	0.0
28 MAR 1983	14:4:56	563	114	7	89	563	114	7	89	0.0
28 MAR 1983	14:32:51	578	88	11	107	565	83	12	110	0.0
27 MAR 1983	1:3:25	584	50	52	277	261	53	54	301	0.0
28 MAR 1983	14:6:29	589	57	39	240	589	57	39	240	0.0
27 MAR 1983	23:43:28	598	55	41	242	598	55	41	242	0.0
28 MAR 1983	19:41:14	599	106	9	123	599	106	9	123	0.0
28 MAR 1983	0:27:39	723	56	56	327	517	57	55	330	0.0
28 MAR 1983	7:54:47	745	61	43	288	660	82	40	359	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
30 MAR 1983	11:46:36	198	16	45	77	80	21	37	86	0.0
31 MAR 1983	22:46:15	205	47	7	37	102	102	1	43	0.0
1 APR 1983	8:8:27	205	43	15	70	114	45	21	103	0.0
1 APR 1983	8:16:22	210	46	7	42	148	77	5	58	0.0
1 APR 1983	8:14:28	213	62	4	42	110	45	6	44	0.0
31 MAR 1983	22:47:21	216	68	5	42	165	34	15	55	0.0
31 MAR 1983	22:52:1	217	72	4	34	195	195	1	46	0.0
31 MAR 1983	22:52:8	217	96	3	34	190	190	1	85	0.0
31 MAR 1983	23:28:3	220	66	8	68	117	50	22	120	0.0
1 APR 1983	1:45:37	220	32	38	133	210	96	10	134	0.0
1 APR 1983	8:19:53	220	147	2	53	193	70	12	93	0.0
31 MAR 1983	22:52:16	222	222	1	31	222	222	1	31	0.0
31 MAR 1983	15:54:46	223	25	21	58	223	25	21	58	0.0
1 APR 1983	8:21:35	225	94	12	128	225	94	12	128	0.0
30 MAR 1983	11:43:29	226	67	4	92	226	67	4	92	0.0
31 MAR 1983	22:59:44	226	226	1	30	215	215	1	32	0.0
31 MAR 1983	22:59:49	226	226	1	31	218	218	1	33	0.0
1 APR 1983	8:19:10	226	50	13	70	143	53	14	80	0.0
31 MAR 1983	22:59:25	227	227	1	29	225	225	1	30	0.0
1 APR 1983	0:40:13	230	35	30	115	209	31	34	118	0.0
1 APR 1983	8:14:20	230	56	9	59	165	59	13	85	0.0
29 MAR 1983	16:3:20	232	66	12	93	204	59	20	135	0.0
1 APR 1983	0:42:47	232	99	3	45	232	99	3	45	0.0
30 MAR 1983	10:30:38	233	68	5	44	194	41	21	97	0.0
31 MAR 1983	22:43:49	233	218	3	75	233	218	3	75	0.0
31 MAR 1983	22:55:3	233	233	1	30	213	213	1	35	0.0
30 MAR 1983	8:31:14	234	44	7	59	133	51	7	66	0.0
1 APR 1983	8:11:7	235	50	9	55	190	43	10	56	0.0
29 MAR 1983	17:15:34	237	24	43	109	231	24	42	112	0.0
31 MAR 1983	22:45:34	237	49	16	84	190	58	14	86	0.0
31 MAR 1983	22:48:34	237	69	7	53	237	69	7	53	0.0
31 MAR 1983	22:52:22	237	237	1	39	191	75	3	46	0.0
1 APR 1983	0:42:16	243	87	7	74	149	66	10	82	0.0
30 APR 1983	4:25:1	243	52	10	65	124	28	23	74	5.3
30 APR 1983	5:15:15	243	97	9	152	243	97	9	152	3.7
1 APR 1983	3:6:34	245	34	49	175	245	34	49	175	0.0
30 MAR 1983	11:55:50	246	25	40	104	230	29	34	107	0.0
31 MAR 1983	21:1:36	252	31	54	177	182	35	59	218	0.0
31 MAR 1983	22:44:32	253	53	7	53	231	71	5	56	0.0
29 MAR 1983	15:23:43	254	61	5	39	249	37	10	42	0.0
30 MAR 1983	19:12:36	254	71	27	201	254	71	27	201	0.0
31 MAR 1983	13:22:49	254	72	5	43	252	72	5	43	0.0
30 APR 1983	3:20:16	254	36	20	83	176	34	21	85	2.6
30 MAR 1983	7:21:13	255	23	39	94	209	25	37	99	0.0
30 MAR 1983	10:41:14	255	86	12	118	255	86	12	118	0.0
31 MAR 1983	22:45:47	255	100	4	68	155	67	14	105	0.0
1 APR 1983	3:45:27	255	28	56	167	205	30	54	168	0.0
1 APR 1983	4:9:24	255	27	54	155	255	27	54	155	0.0
1 APR 1983	8:22:42	256	73	7	108	256	73	7	108	0.0
29 MAR 1983	16:49:58	257	40	9	67	108	15	44	70	0.0

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
31 MAR 1983	10:48:2	258	46	16	79	231	120	5	94	0.0
1 APR 1983	8:31:7	258	55	8	81	216	56	15	92	0.0
31 MAR 1983	22:48:7	260	103	3	44	197	33	18	67	0.0
1 APR 1983	1:47:51	260	23	47	113	128	26	50	138	0.0
1 APR 1983	8:23:18	260	101	5	59	190	65	14	99	0.0
30 APR 1983	11:54:26	260	88	6	78	188	77	8	95	8.4
30 MAR 1983	9:32:0	261	74	16	133	231	106	11	137	0.0
31 MAR 1983	22:39:18	261	82	5	50	94	41	12	58	0.0
30 APR 1983	8:40:23	261	50	16	100	261	50	16	100	1.4
30 MAR 1983	12:26:5	263	49	8	64	263	49	8	64	0.0
30 MAR 1983	19:6:58	266	66	5	43	266	66	5	43	0.0
31 MAR 1983	11:19:10	266	82	5	48	258	47	13	74	0.0
30 APR 1983	7:21:30	267	56	9	59	249	67	10	100	2.9
2 APR 1983	13:23:39	268	62	20	145	258	71	20	162	0.0
30 MAR 1983	8:44:9	269	37	13	62	202	23	39	95	0.0
1 APR 1983	0:36:30	269	57	14	97	269	57	14	97	0.0
30 APR 1983	6:14:18	270	42	18	97	252	133	4	99	2.9
30 APR 1983	11:12:16	270	67	8	82	215	67	20	148	10.3
30 APR 1983	4:59:47	271	56	11	75	271	56	11	75	4.2
29 MAR 1983	17:18:1	272	19	45	93	272	19	45	93	0.0
1 APR 1983	8:24:32	272	57	14	87	272	57	14	87	0.0
30 APR 1983	5:24:51	272	27	29	87	222	28	39	121	4.4
30 APR 1983	7:25:15	273	33	15	55	198	22	25	59	7.1
30 APR 1983	8:39:52	273	72	13	105	243	71	12	117	7.7
1 APR 1983	8:21:42	274	104	6	90	265	95	8	97	0.0
31 MAR 1983	9:52:38	275	83	4	37	275	83	4	37	0.0
31 MAR 1983	22:47:10	275	121	6	81	275	121	6	81	0.0
1 APR 1983	3:44:30	275	26	53	144	275	26	53	144	0.0
30 APR 1983	1:22:55	275	39	10	48	138	30	23	76	6.7
30 APR 1983	6:18:28	275	56	8	66	275	56	8	66	3.8
30 APR 1983	3:2:4	276	55	10	72	188	20	50	106	9.8
30 MAR 1983	12:26:51	277	70	10	82	277	70	10	82	0.0
31 MAR 1983	9:56:32	278	92	6	66	209	55	12	91	0.0
29 MAR 1983	13:17:49	279	103	5	75	225	112	5	82	0.0
29 MAR 1983	15:59:54	279	98	13	149	279	98	13	149	0.0
29 MAR 1983	16:6:28	280	26	43	120	280	26	43	120	0.0
31 MAR 1983	10:29:31	280	54	20	113	280	54	20	113	0.0
30 APR 1983	3:13:3	280	280	1	50	250	22	23	71	5.2
30 MAR 1983	10:40:0	282	79	8	73	282	79	8	73	0.0
1 APR 1983	2:9:13	283	27	53	153	234	32	55	185	0.0
30 MAR 1983	16:57:39	284	73	9	70	125	60	13	82	0.0
1 APR 1983	4:53:29	284	53	8	64	240	27	38	107	0.0
30 APR 1983	12:18:52	284	119	3	41	114	114	1	44	6.5
31 MAR 1983	13:10:36	285	89	5	48	285	89	5	48	0.0
29 MAR 1983	15:22:56	286	66	9	75	219	50	17	91	0.0
29 MAR 1983	16:6:58	286	43	14	72	257	22	35	85	0.0
30 MAR 1983	8:44:17	286	119	3	61	286	119	3	61	0.0
31 MAR 1983	10:25:45	286	50	14	74	286	50	14	74	0.0
31 MAR 1983	10:50:35	287	241	3	87	287	241	3	87	0.0
30 MAR 1983	17:2:10	288	98	7	66	252	68	11	79	0.0

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
30 MAR 1983	12:26:40	290	104	4	69	202	67	8	78	0.0
31 MAR 1983	10:49:8	290	95	7	79	196	90	11	107	0.0
30 APR 1983	10:53:10	290	48	8	51	255	51	10	61	4.8
30 APR 1983	14:43:56	290	87	15	141	269	77	18	148	.5
30 MAR 1983	18:5:40	291	133	3	61	214	63	12	79	0.0
31 MAR 1983	13:23:5	291	109	4	49	284	109	4	51	0.0
1 APR 1983	8:22:57	293	69	11	86	249	175	4	90	0.0
30 APR 1983	1:14:53	293	54	9	56	284	27	27	80	4.1
30 APR 1983	7:52:14	293	46	20	102	293	46	20	102	2.2
30 APR 1983	7:54:53	294	45	15	107	294	45	15	107	3.1
30 APR 1983	12:17:58	294	65	9	66	261	87	10	95	8.0
29 MAR 1983	13:17:25	295	16	46	78	213	25	35	97	0.0
31 MAR 1983	13:22:38	295	74	5	42	293	75	5	45	0.0
31 MAR 1983	13:19:22	296	38	19	78	296	38	19	78	0.0
31 MAR 1983	22:48:22	296	48	11	57	250	52	17	97	0.0
2 APR 1983	22:45:31	296	84	8	76	251	88	8	78	0.0
30 APR 1983	6:31:33	296	85	5	70	254	74	5	81	3.6
31 MAR 1983	13:22:34	297	68	5	41	295	68	5	42	0.0
1 APR 1983	9:53:2	297	117	9	120	297	117	9	120	0.0
29 MAR 1983	17:22:49	298	29	42	135	292	31	42	148	0.0
30 MAR 1983	6:24:39	298	55	15	124	161	62	19	161	0.0
30 MAR 1983	10:40:12	299	96	10	107	299	96	10	107	0.0
29 MAR 1983	7:53:3	300	55	8	63	300	55	8	63	0.0
2 APR 1983	21:34:23	300	30	39	124	229	30	43	137	0.0
29 MAR 1983	17:19:36	301	25	46	126	234	27	46	137	0.0
2 APR 1983	21:33:46	301	30	36	117	296	39	31	130	0.0
30 APR 1983	6:11:2	301	43	24	125	301	43	24	125	8.2
31 MAR 1983	22:47:27	302	44	16	76	302	44	16	76	0.0
1 APR 1983	8:21:53	302	68	25	185	254	92	24	237	0.0
30 MAR 1983	8:54:11	303	21	48	107	303	21	48	107	0.0
31 MAR 1983	13:22:43	303	80	5	47	303	80	5	47	0.0
31 MAR 1983	21:9:32	304	47	57	282	248	47	57	283	0.0
31 MAR 1983	22:55:8	304	60	12	102	280	71	13	121	0.0
2 APR 1983	22:32:17	304	48	21	108	222	57	19	117	0.0
31 MAR 1983	9:31:55	305	47	29	143	305	47	29	143	0.0
30 APR 1983	1:52:16	305	41	11	49	222	50	9	50	8.5
31 MAR 1983	12:52:32	306	98	6	67	153	89	10	99	0.0
2 APR 1983	15:35:48	306	32	44	147	306	32	44	147	0.0
2 APR 1983	21:35:11	306	45	40	191	231	46	41	198	0.0
30 APR 1983	3:3:56	306	84	5	64	207	108	4	70	4.0
30 APR 1983	3:27:3	306	45	30	144	306	45	30	144	7.3
29 MAR 1983	15:58:55	308	25	30	106	224	49	22	119	0.0
30 MAR 1983	17:0:5	309	174	2	43	309	174	2	43	0.0
29 MAR 1983	16:0:4	310	44	12	70	310	44	12	70	0.0
30 APR 1983	7:11:14	310	40	16	78	310	40	16	78	5.3
31 MAR 1983	13:22:28	311	113	3	40	309	112	3	40	0.0
1 APR 1983	1:31:14	311	177	2	119	261	174	2	127	0.0
1 APR 1983	7:1:19	311	31	22	77	311	31	22	77	0.0
30 APR 1983	14:11:46	313	54	13	80	313	54	13	80	.4
30 APR 1983	1:57:48	316	50	20	105	291	60	17	110	7.1

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
30 MAR 1983	18:14:18	317	72	8	61	317	72	8	61	0.0
1 APR 1963	8:20:35	317	60	16	105	317	60	16	105	0.0
30 APR 1983	1:57:31	319	43	21	95	319	43	21	95	11.3
1 APR 1983	1:25:36	320	31	26	98	320	31	26	98	0.0
30 APR 1983	2:19:52	320	50	18	104	320	50	18	104	8.4
30 MAR 1983	6:26:40	322	26	44	121	322	26	44	121	0.0
31 MAR 1983	13:32:48	322	101	6	72	322	101	6	72	0.0
30 MAR 1993	10:33:58	323	89	6	63	261	73	11	90	0.0
1 APR 1983	8:22:23	324	134	4	63	202	70	14	107	0.0
30 APR 1983	2:41:34	324	324	1	66	324	324	1	66	4.4
30 MAR 1983	10:32:59	325	68	15	114	325	68	15	114	0.0
2 APR 1983	22:19:12	325	74	10	89	325	74	10	89	0.0
30 MAR 1983	9:17:8	326	71	12	101	326	71	12	101	0.0
30 MAR 1983	17:15:39	326	66	7	50	306	122	7	92	0.0
2 APR 1983	13:42:23	326	156	6	143	177	64	25	177	0.0
29 MAR 1983	7:52:32	327	79	17	149	327	79	17	149	0.0
2 APR 1983	21:36:33	328	35	48	180	328	35	48	180	0.0
30 APR 1983	2:26:45	328	61	16	121	276	78	16	143	10.9
2 APR 1983	22:35:5	330	79	6	59	330	79	6	59	0.0
2 APR 1983	22:51:55	332	51	22	122	271	50	23	127	0.0
30 APR 1983	2:4:52	332	48	20	109	332	48	20	109	4.1
31 MAR 1983	22:47:48	333	112	7	89	327	129	8	112	0.0
30 MAR 1983	17:8:0	334	129	4	59	334	129	4	59	0.0
31 MAR 1983	11:0:14	334	78	5	48	159	60	7	51	0.0
30 APR 1983	3:3:22	334	28	20	72	334	28	20	72	4.9
29 MAR 1983	16:7:56	335	38	39	156	218	60	23	157	0.0
29 MAR 1983	17:24:44	335	30	42	153	250	39	41	175	0.0
31 MAR 1983	15:5:8	335	102	12	137	335	102	12	137	0.0
1 APR 1983	1:20:35	336	25	48	125	283	26	48	132	0.0
30 APR 1983	12:20:40	338	57	19	124	338	57	19	124	7.4
29 MAR 1983	16:25:15	339	33	21	85	302	20	39	85	0.0
31 MAR 1983	13:10:0	339	339	1	60	339	339	1	60	0.0
31 MAR 1983	9:52:30	340	56	10	62	340	56	10	62	0.0
30 MAR 1983	16:59:53	341	89	7	69	335	117	6	78	0.0
31 MAR 1983	10:47:56	341	104	9	102	341	104	9	102	0.0
30 APR 1983	8:36:16	342	35	34	125	342	35	34	125	1.9
30 MAR 1983	11:46:16	343	27	35	101	286	41	26	116	0.0
1 APR 1983	8:30:51	343	60	20	131	291	65	20	142	0.0
30 APR 1983	1:46:58	345	57	31	130	212	33	36	137	11.9
30 APR 1983	3:22:58	345	49	12	73	345	49	12	73	6.3
2 APR 1983	13:39:47	347	45	22	114	347	45	22	114	0.0
30 APR 1983	5:21:22	347	23	33	84	325	38	16	84	6.4
30 APR 1983	6:33:30	347	47	20	104	304	38	27	116	1.8
31 MAR 1983	22:40:33	349	118	5	96	291	117	5	99	0.0
31 MAR 1983	22:55:19	350	53	13	77	248	50	14	77	0.0
1 APR 1983	7:19:45	353	161	4	76	353	161	4	76	0.0
2 APR 1983	13:43:35	355	52	33	180	355	52	33	180	0.0
30 APR 1983	14:59:30	356	105	7	80	356	105	7	80	9.2
29 MAR 1983	15:41:47	357	37	16	75	169	29	24	77	0.0
30 MAR 1983	12:28:25	360	63	10	83	360	63	10	83	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
29 MAR 1983	15:48:56	362	24	28	81	265	42	23	110	0.0
31 MAR 1983	22:55:14	362	105	4	59	264	91	5	60	0.0
1 APR 1983	8:3:21	352	208	2	58	362	208	2	58	0.0
31 MAR 1983	10:51:4	365	82	11	99	318	124	8	113	0.0
31 MAR 1983	22:47:35	365	223	3	97	365	223	3	97	0.0
31 MAR 1983	15:17:54	367	121	6	103	229	150	5	105	0.0
30 APR 1983	2:17:49	368	38	16	68	242	48	13	71	9.0
30 APR 1983	3:19:49	369	98	4	63	369	98	4	63	3.0
30 MAR 1983	8:1:3	370	22	33	82	370	22	33	82	0.0
30 APR 1983	13:50:10	370	183	3	110	249	45	32	151	5.6
30 MAR 1983	12:38:40	371	77	9	77	233	45	18	66	0.0
1 APR 1983	9:19:13	371	152	6	102	333	69	15	114	0.0
2 APR 1983	13:43:56	371	79	21	181	371	79	21	181	0.0
30 MAR 1983	9:51:2	372	111	4	57	159	116	4	60	0.0
30 APR 1983	4:42:47	375	33	16	80	361	81	6	82	4.4
2 APR 1983	13:21:57	376	84	20	192	306	85	21	203	0.0
30 APR 1983	6:19:26	377	39	17	87	377	39	17	87	3.2
30 MAR 1983	12:27:48	378	73	10	86	347	38	24	97	0.0
31 MAR 1983	22:49:11	380	119	4	55	340	66	13	93	0.0
2 APR 1983	12:58:2	380	42	24	116	380	42	24	116	0.0
30 APR 1983	1:21:45	381	54	15	91	249	51	18	101	10.1
30 APR 1983	10:54:24	382	188	3	74	289	92	7	75	5.7
1 APR 1983	9:24:51	384	140	5	143	285	181	4	145	0.0
2 APR 1983	12:58:26	384	106	9	105	384	106	9	105	0.0
2 APR 1983	21:47:14	384	76	15	135	338	89	15	153	0.0
30 APR 1983	7:22:13	384	164	4	76	229	44	22	103	1.2
29 MAR 1983	8:24:9	385	89	9	99	352	92	9	100	0.0
30 MAR 1983	12:35:24	385	58	15	96	385	58	15	95	0.0
2 APR 1983	22:19:23	387	112	7	88	176	50	21	114	0.0
30 APR 1983	12:15:42	388	59	14	89	316	64	13	89	8.8
29 MAR 1983	13:18:11	389	41	51	222	389	41	51	222	0.0
2 APR 1983	22:45:12	389	81	13	116	389	81	13	116	0.0
29 MAR 1983	16:10:0	391	59	25	167	238	41	44	190	0.0
1 APR 1983	8:18:44	391	144	7	115	230	72	15	116	0.0
29 MAR 1983	13:28:25	394	45	47	226	394	45	47	226	0.0
29 MAR 1983	15:57:6	396	135	14	206	376	113	17	208	0.0
31 MAR 1983	12:51:53	397	37	39	154	303	36	40	155	0.0
30 APR 1983	7:45:25	397	33	17	70	114	34	17	76	2.8
30 MAR 1983	11:43:35	398	39	13	60	398	39	13	60	0.0
29 MAR 1983	13:15:42	399	26	41	114	399	26	41	114	0.0
30 APR 1983	7:39:37	400	37	19	81	170	32	35	120	5.1
31 MAR 1983	13:10:9	401	73	10	82	401	73	10	82	0.0
29 MAR 1983	13:22:48	404	62	12	66	333	37	29	113	0.0
30 APR 1983	15:24:19	404	62	9	61	404	62	9	61	7.4
30 MAR 1983	17:50:57	407	92	19	187	317	90	22	212	0.0
30 APR 1983	1:48:52	407	29	31	97	372	35	23	98	10.8
30 APR 1983	7:39:59	408	55	13	85	408	55	13	85	3.3
30 MAR 1993	12:33:14	412	67	13	101	412	67	13	101	0.0
2 APR 1983	22:18:46	412	63	14	96	374	102	15	166	0.0
30 APR 1983	14:14:0	413	58	19	117	329	124	7	118	1.3

DATE	TIME	FM1	FA1	A1	F1	FM2	FA2	A2	F2	VEL
30 APR 1983	12:9:6	414	308	2	76	414	308	2	76	9.9
30 MAR 1983	11:46:34	415	27	30	88	284	57	15	99	0.0
1 APR 1983	6:25:5	417	137	4	78	287	126	4	81	0.0
2 APR 1983	17:53:57	421	165	4	101	421	165	4	101	0.0
2 APR 1983	22:18:22	424	30	28	89	346	36	24	93	0.0
2 APR 1983	21:29:30	425	214	3	114	409	113	6	117	0.0
2 APR 1983	22:45:44	435	254	3	105	435	254	3	105	0.0
2 APR 1983	22:7:21	437	31	35	113	413	41	32	143	0.0
30 APR 1983	7:39:52	437	50	17	96	437	50	17	95	4.2
30 APR 1983	2:18:57	438	95	10	108	438	95	10	108	10.0
31 MAR 1983	12:17:3	440	148	6	98	428	132	7	101	0.0
31 MAR 1983	11:29:50	445	78	13	114	376	97	12	131	0.0
31 MAR 1983	21:15:15	445	36	55	209	275	39	55	228	0.0
1 APR 1983	6:25:10	445	22	34	81	313	152	4	85	0.0
30 MAR 1983	6:29:23	447	28	32	127	447	28	32	127	0.0
31 MAR 1983	22:48:27	449	140	8	135	449	140	8	135	0.0
2 APR 1983	12:58:48	449	45	16	83	449	45	16	83	0.0
29 MAR 1983	15:47:31	451	101	5	80	451	101	5	80	0.0
30 APR 1983	12:14:42	453	50	33	175	276	90	18	181	9.7
2 APR 1983	22:17:43	454	40	25	112	416	49	20	113	0.0
2 APR 1983	13:9:39	469	260	6	201	444	271	6	207	0.0
30 APR 1983	1:56:53	471	56	45	268	471	56	45	268	12.4
2 APR 1983	20:36:23	472	24	39	103	312	38	25	126	0.0
30 APR 1983	11:11:51	477	25	37	101	319	59	23	157	12.2
1 APR 1983	6:24:17	480	213	4	96	459	414	2	105	0.0
31 MAR 1983	13:21:19	482	90	7	71	270	75	9	74	0.0
2 APR 1983	19:29:48	487	41	43	189	460	51	44	239	0.0
31 MAR 1983	10:38:41	495	111	11	135	495	111	11	135	0.0
29 MAR 1983	13:16:8	507	33	34	123	370	30	43	133	0.0
2 APR 1983	13:18:12	510	100	11	127	300	34	37	131	0.0
29 MAR 1983	7:53:9	520	89	9	126	498	89	9	127	0.0
2 APR 1983	13:22:47	524	68	25	186	524	68	25	186	0.0
30 MAR 1983	6:24:13	561	55	43	247	561	55	43	247	0.0
30 APR 1983	1:39:21	566	107	12	144	566	107	12	144	4.6
31 MAR 1983	10:38:47	568	110	8	97	568	110	8	97	0.0
2 APR 1983	22:14:15	570	90	8	76	570	90	8	76	0.0
30 APR 1983	12:16:48	571	47	36	178	502	46	37	181	7.1
30 APR 1983	12:16:35	589	110	16	203	589	110	16	203	10.3
30 MAR 1983	12:19:27	592	65	16	134	326	74	16	141	0.0
2 APR 1983	21:46:53	598	46	33	179	598	46	33	179	0.0
1 APR 1983	1:20:58	602	30	49	152	585	31	48	155	0.0
2 APR 1983	21:28:53	611	135	21	310	611	135	21	310	0.0
29 MAR 1983	13:31:54	640	81	24	213	640	81	24	213	0.0
2 APR 1983	20:40:44	676	32	46	153	676	32	46	153	0.0
30 MAR 1983	10:29:21	684	113	19	231	684	113	19	231	0.0
30 APR 1983	1:39:50	764	117	16	205	696	131	15	214	3.5
2 APR 1983	23:0:25	783	232	9	231	525	245	9	254	0.0
30 APR 1983	12:16:55	851	189	10	204	851	189	10	204	5.6
2 APR 1983	21:29:46	1010	41	53	229	319	51	54	287	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 APR 1983	19:42:37	147	39	11	56	103	27	12	62	4.2
12 APR 1983	19:43:49	155	30	9	54	134	49	7	79	4.5
8 APR 1983	18:28:31	175	175	1	31	111	24	18	50	-.2
8 APR 1983	18:35:59	182	182	1	25	128	30	9	37	-.3
8 APR 1983	18:35:41	185	61	7	57	185	61	7	57	-.2
26 APR 1983	21:18:21	189	34	36	139	177	37	34	145	2.1
24 APR 1983	19:50:10	190	31	15	54	153	29	17	56	5.0
16 APR 1983	13:27:31	205	33	10	41	191	55	8	60	1.8
8 APR 1983	18:36:23	220	38	8	44	127	25	19	53	-.2
3 APR 1983	4:14:51	221	64	24	168	205	63	25	171	0.0
3 APR 1983	4:31:53	241	84	18	172	241	84	18	172	0.0
3 APR 1983	2:32:7	245	49	55	282	241	49	55	283	0.0
7 APR 1983	15:13:55	245	86	3	28	245	86	3	28	0.0
12 APR 1983	17:38:52	247	30	53	169	234	31	54	174	3.3
3 APR 1983	1:42:16	249	44	54	250	243	46	53	257	0.0
8 APR 1983	7:46:52	252	30	55	175	252	30	55	175	6.0
2 APR 1983	23:32:40	257	79	17	145	257	79	17	145	0.0
3 APR 1983	4:32:35	260	62	20	134	260	62	20	134	0.0
12 APR 1983	16:15:35	260	41	33	150	241	40	38	158	2.4
3 APR 1983	2:43:10	262	52	55	302	200	53	55	304	0.0
3 APR 1983	2:56:29	264	53	57	318	155	66	56	387	0.0
3 APR 1983	2:43:54	267	52	55	299	171	58	56	341	0.0
3 APR 1983	3:27:2	268	55	54	312	245	59	54	334	0.0
12 APR 1983	19:41:25	268	22	31	82	238	30	23	90	4.7
25 APR 1983	17:31:24	269	36	18	69	123	34	31	112	7.3
3 APR 1983	3:6:15	270	56	55	324	193	65	54	368	0.0
3 APR 1983	3:0:34	272	55	55	316	257	59	54	336	0.0
7 APR 1983	14:40:22	274	45	17	87	238	50	20	111	0.0
21 APR 1983	9:25:22	274	81	20	175	194	75	23	185	4.7
2 APR 1983	23:31:12	275	68	18	134	193	72	19	149	0.0
3 APR 1983	3:3:29	275	57	56	337	263	59	55	339	0.0
7 APR 1983	15:1:2	275	122	3	43	166	74	5	45	0.0
12 APR 1983	17:47:12	275	32	56	190	200	40	57	238	5.3
2 APR 1983	23:33:46	276	108	12	141	276	108	12	141	0.0
3 APR 1983	0:29:57	276	49	26	136	276	49	26	136	0.0
3 APR 1983	1:42:43	276	39	54	219	266	39	54	221	0.0
3 APR 1983	3:0:41	276	56	55	324	245	55	56	324	0.0
12 APR 1983	16:23:22	276	51	28	152	272	55	26	153	2.2
11 APR 1983	14:10:30	277	119	4	57	212	31	18	63	3.6
3 APR 1983	2:59:23	278	57	54	323	257	57	55	330	0.0
2 APR 1983	23:35:39	279	93	14	143	279	93	14	143	0.0
3 APR 1983	1:3:17	280	41	48	205	252	43	49	223	0.0
3 APR 1983	2:59:31	280	61	55	352	280	64	56	374	0.0
9 APR 1983	10:4:53	280	174	3	61	159	64	10	74	11.7
7 APR 1983	14:44:25	281	65	20	152	266	69	20	159	0.0
3 APR 1983	2:52:12	284	54	55	314	234	55	55	320	0.0
8 APR 1983	18:32:54	284	56	12	80	284	56	12	80	-.3
12 APR 1983	17:44:6	285	40	56	238	264	43	55	250	5.4
3 APR 1983	3:28:16	288	51	54	287	147	59	54	334	0.0
3 APR 1983	0:28:57	291	44	22	104	244	55	10	107	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
3 APR 1983	3:4:20	291	53	57	319	198	57	58	344	0.0
7 APR 1983	15:43:14	291	39	18	79	280	48	15	81	0.0
8 APR 1983	12:24:52	291	88	8	84	284	89	8	85	6.3
8 APR 1983	7:46:42	292	31	57	187	268	33	55	191	7.5
3 APR 1983	1:19:26	293	29	54	165	291	32	52	172	0.0
24 APR 1983	22:7:40	293	16	40	67	135	17	43	80	3.2
3 APR 1983	3:3:21	294	52	56	303	272	53	57	320	0.0
12 APR 1983	16:25:49	294	73	16	129	268	60	21	141	1.5
12 APR 1983	17:51:43	294	35	56	208	193	35	58	214	1.7
3 APR 1983	1:22:15	295	33	53	184	260	34	52	185	0.0
3 APR 1983	3:1:7	295	62	56	362	295	62	56	362	0.0
7 APR 1983	15:8:48	295	114	3	41	269	188	2	44	0.0
25 APR 1983	18:44:29	296	37	44	173	296	37	44	173	2.7
3 APR 1983	0:18:34	297	83	12	110	282	61	19	124	0.0
3 APR 1983	2:8:43	297	44	55	253	297	44	55	253	0.0
3 APR 1983	3:9:16	297	58	58	355	297	58	58	355	0.0
2 APR 1983	23:28:27	298	86	12	114	192	55	20	121	0.0
11 APR 1983	13:35:20	299	225	2	52	295	38	13	69	7.2
3 APR 1983	0:20:28	300	150	4	90	283	90	17	168	0.0
3 APR 1983	0:33:59	300	45	26	131	300	45	26	131	0.0
3 APR 1983	3:1:17	300	56	54	316	146	56	56	330	0.0
3 APR 1983	3:32:39	301	48	55	280	156	49	55	281	0.0
11 APR 1983	13:15:0	302	83	14	128	302	83	14	128	4.9
21 APR 1983	9:54:43	302	65	11	77	172	26	31	98	5.5
27 APR 1983	0:6:8	302	29	37	114	196	29	37	120	9.7
3 APR 1983	1:42:49	303	32	52	173	303	32	52	173	0.0
3 APR 1983	3:4:12	303	60	57	357	244	59	58	357	0.0
3 APR 1983	3:7:55	303	65	56	383	303	65	56	383	0.0
3 APR 1983	4:34:52	303	70	18	150	168	60	22	150	0.0
3 APR 1983	3:18:8	304	52	54	293	162	53	55	305	0.0
27 APR 1983	8:28:19	305	28	36	127	291	54	32	183	1.2
2 APR 1983	23:22:57	307	88	14	138	306	103	13	150	0.0
2 APR 1983	23:34:3	309	64	16	111	248	79	20	170	0.0
19 APR 1983	13:12:30	309	103	5	59	301	175	3	62	7.0
25 APR 1983	20:21:20	309	85	8	74	300	72	10	77	.7
2 APR 1983	23:18:58	310	64	20	138	254	72	20	153	0.0
9 APR 1983	11:10:20	310	93	8	81	275	129	6	85	8.3
11 APR 1983	13:28:34	310	32	40	134	310	32	40	134	6.4
3 APR 1983	2:38:33	312	51	56	298	167	55	54	310	0.0
3 APR 1983	3:0:2	312	60	54	340	210	64	55	371	0.0
19 APR 1983	13:8:2	312	63	12	83	217	50	24	126	44.5
24 APR 1983	16:16:58	312	63	15	105	256	60	16	108	.8
2 APR 1983	23:28:14	313	56	17	104	190	59	21	134	0.0
3 APR 1983	3:24:5	313	58	54	327	234	60	54	341	0.0
24 APR 1983	21:43:49	313	60	12	83	291	29	27	85	9.6
3 APR 1983	0:11:3	315	60	19	122	315	60	19	122	0.0
2 APR 1983	23:23:21	316	66	11	102	271	58	18	115	0.0
3 APR 1983	2:1:20	316	40	55	229	214	46	54	260	0.0
11 APR 1983	12:43:24	316	121	3	43	176	32	13	54	6.5
7 APR 1983	15:43:32	317	138	4	63	317	138	4	63	0.0

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
2 APR 1983	23:33:40	319	90	11	110	319	90	11	110	0.0
20 APR 1983	13:53:18	320	48	42	210	275	50	49	259	6.1
24 APR 1983	16:16:38	320	132	7	107	302	138	7	110	5.9
3 APR 1983	0:29:19	321	55	25	145	321	55	25	145	0.0
3 APR 1983	0:30:48	321	55	20	122	186	58	25	157	0.0
3 APR 1983	2:59:50	321	54	54	305	187	58	55	336	0.0
3 APR 1983	2:39:27	322	62	54	353	322	62	54	353	0.0
19 APR 1983	13:36:20	322	39	20	86	194	46	21	102	1.9
11 APR 1983	13:31:37	323	53	18	101	210	56	19	115	6.6
16 APR 1983	11:52:30	323	101	4	42	310	85	4	43	5.0
24 APR 1983	19:8:3	323	45	27	128	255	49	28	144	8.6
2 APR 1983	23:20:49	324	55	15	89	158	58	17	108	0.0
2.APR 1983	23:22:40	325	89	8	78	290	124	11	150	0.0
3 APR 1983	0:12:55	325	74	11	90	140	59	15	95	0.0
19 APR 1983	13:38:19	325	34	33	116	274	34	34	123	1.0
2 APR 1983	23:19:50	326	51	19	104	326	51	19	104	0.0
2 APR 1983	23:23:58	326	81	10	94	.326	81	10	94	0.0
3 APR 1983	3:14:2	326	55	54	313	193	56	55	320	0.0
7 APR 1983	15:42:49	326	50	23	124	326	50	23	124	0.0
9 APR 1983	9:8:45	326	39	17	75	326	39	17	75	4.3
24 APR 1983	18:22:1	327	134	3	45	248	67	7	54	4.3
7 APR 1983	14:56:43	328	89	13	140	322	115	12	158	0.0
12 APR 1983	20:21:8	328	328	1	80	316	316	1	105	3.7
24 APR 1983	19:11:57	328	77	6	55	318	86	6	61	5.5
7 APR 1983	14:56:54	329	54	14	85	329	54	14	85	0.0
11 APR 1983	11:23:38	329	59	13	85	214	99	9	100	5.5
24 APR 1983	16:16:52	329	99	7	93	317	122	6	98	1.6
24 APR 1983	21:53:59	329	43	13	81	168	109	5	100	5.6
3 APR 1983	0:27:37	333	78	14	123	209	61	22	145	0.0
3 APR 1983	0:29:10	333	141	5	97	309	47	24	123	0.0
11 APR 1983	9:38:49	333	89	5	52	314	66	9	78	5.0
9 APR 1983	10:36:31	334	30	21	69	252	59	14	90	6.7
8 APR 1983	12:40:22	335	82	6	56	335	82	6	56	6.8
8 APR 1983	15:57:50	335	109	18	211	303	104	21	230	-.3
2 APR 1983	23:19:18	336	84	7	67	248	76	8	69	0.0
2 APR 1983	23:35:14	335	107	11	136	245	84	19	174	0.0
19 APR 1983	13:6:23	336	19	32	64	178	63	18	123	1.0
24 APR 1983	22:5:7	336	21	37	81	238	27	29	89	6.2
25 APR 1983	20:16:7	336	92	7	79	205	61	13	88	4.2
2 APR 1983	23:28:6	337	82	10	90	301	75	11	92	0.0
3 APR 1983	0:17:21	337	81	23	202	330	105	20	227	0.0
7 APR 1983	14:52:57	337	66	19	144	337	66	19	144	0.0
25 APR 1983	17:36:18	337	258	2	63	310	262	2	63	2.0
26 APR 1983	4:28:26	337	65	8	63	77	18	43	83	6.3
3 APR 1983	0:7:35	338	70	9	71	185	60	11	75	0.0
3 APR 1983	0:34:29	338	48	20	121	319	42	32	141	0.0
3 APR 1983	2:49:8	338	56	57	333	338	56	57	333	0.0
19 APR 1983	12:51:52	338	57	20	123	338	57	20	123	.8
24 APR 1983	14:3:53	338	110	6	75	264	100	7	80	2.7
2 APR 1983	23:24:49	339	80	16	143	339	80	16	143	0.0

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
11 APR 1983	12:0:45	339	101	6	79	247	106	6	84	5.3
11 APR 1983	12:29:12	339	41	29	133	308	40	35	152	1.6
12 APR 1983	18:14:44	339	44	57	264	312	46	57	276	4.6
14 APR 1983	18:12:20	340	96	7	74	257	185	4	84	9.4
2 APR 1983	23:15:46	341	68	19	138	254	72	22	173	0.0
24 APR 1983	18:47:51	341	42	20	90	209	46	19	93	3.6
11 APR 1983	11:54:25	343	83	10	94	311	106	8	97	8.8
8 APR 1983	15:21:57	344	112	6	115	344	112	6	115	-.3
20 APR 1983	15:56:32	345	91	15	151	345	91	15	151	2.9
8 APR 1983	0:35:46	346	30	46	148	328	30	47	149	0.0
11 APR 1983	11:41:39	346	92	10	101	266	90	11	106	7.4
14 APR 1983	16:26:53	346	118	6	87	346	118	6	87	10.5
14 APR 1983	17:45:27	346	118	6	87	346	118	6	87	10.2
25 APR 1983	21:17:6	346	52	14	79	286	57	15	91	1.1
11 APR 1983	11:56:13	347	67	7	53	122	36	17	78	8.4
25 APR 1983	17:47:36	348	43	31	142	329	45	30	146	3.5
3 APR 1983	2:52:4	349	58	57	348	283	59	57	355	0.0
25 APR 1983	17:8:3	349	81	8	75	307	91	11	108	3.3
25 APR 1983	17:8:9	349	195	3	67	319	200	3	67	3.8
26 APR 1983	3:45:20	349	62	8	57	335	103	5	60	5.9
12 APR 1983	14:35:42	350	35	41	152	350	35	41	152	8.0
9 APR 1983	10:14:46	351	54	11	95	338	51	12	100	6.8
11 APR 1993	11:52:55	352	128	4	57	173	59	19	121	4.7
24 APR 1983	19:9:45	352	61	10	75	299	57	12	78	8.6
3 APR 1983	0:29:36	353	53	23	132	341	74	19	153	0.0
16 APR 1983	13:3:2	354	79	8	68	256	95	8	90	1.5
2 APR 1983	23:31:54	355	92	11	112	309	109	12	143	0.0
21 APR 1983	9:42:29	355	56	21	126	293	53	24	135	2.0
24 APR 1983	18:41:5	356	48	36	182	235	43	43	195	2.0
9 APR 1983	10:37:3	357	43	18	88	357	43	18	88	7.4
11 APR 1983	8:36:1	358	115	4	67	315	54	11	69	3.9
12 APR 1983	20:49:33	358	139	3	89	290	122	9	121	2.5
7 APR 1983	14:44:37	359	43	20	105	359	43	20	105	0.0
9 APR 1983	10:36:10	359	34	32	115	359	34	32	115	6.6
11 APR 1983	13:48:53	359	91	8	103	321	64	27	183	7.8
12 APR 1983	16:12:30	360	23	36	88	359	22	38	89	2.8
24 APR 1983	20:55:2	360	34	16	74	163	47	16	94	8.2
3 APR 1983	0:7:20	362	84	13	125	273	56	23	140	0.0
3 APR 1983	2:9:0	362	49	55	285	178	51	54	288	0.0
21 APR 1983	9:22:53	362	58	19	124	255	43	32	146	1.1
3 APR 1983	0:27:48	363	114	10	128	182	60	22	148	0.0
9 APR 1983	11:23:0	363	91	5	57	151	90	4	82	9.2
11 APR 1983	8:50:10	364	35	38	140	363	37	37	143	7.7
11 APR 1983	11:23:43	364	68	16	119	361	65	17	120	3.0
24 APR 1983	15:23:26	364	38	36	145	245	50	37	195	4.8
3 APR 1983	3:3:58	365	53	56	314	297	55	56	323	0.0
9 APR 1983	10:15:30	365	79	28	240	288	64	38	255	7.4
2 APR 1983	23:29:46	366	86	12	114	157	88	12	117	0.0
12 APR 1983	14:35:15	366	63	12	91	296	77	10	94	7.9
24 APR 1983	21:49:53	366	14	49	72	331	258	2	80	6.9

DATE	TIME	FM1	PA1	A1	F1	FM2	PA2	A2	F2	VEL
16 APR 1983	12:58:40	367	73	14	146	365	73	22	171	2.1
25 APR 1983	19:48:37	367	152	3	52	254	58	13	87	5.7
12 APR 1983	20:37:9	368	204	4	92	368	204	4	92	5.2
24 APR 1983	18:51:53	369	136	6	94	346	33	31	109	4.0
3 APR 1983	2:53:7	370	55	56	322	227	56	57	337	0.0
8 APR 1983	18:7:3	370	64	9	75	363	61	10	77	-.2
12 APR 1983	20:1:18	370	78	7	102	370	78	7	102	2.4
24 APR 1983	22:55:35	370	20	46	95	248	87	8	102	3.3
2 APR 1983	23:17:29	371	83	16	142	339	99	17	184	0.0
25 APR 1983	20:49:15	372	236	2	57	330	248	2	60	2.3
12 APR 1983	18:14:35	373	45	57	268	373	45	57	258	6.2
3 APR 1983	0:8:17	374	104	17	196	374	104	17	196	0.0
27 APR 1983	8:27:49	374	44	32	150	317	50	33	179	1.9
21 APR 1983	9:46:18	377	72	13	117	377	72	13	117	4.2
3 APR 1983	0:9:39	378	65	17	119	378	65	17	119	0.0
24 APR 1983	21:45:42	378	97	5	58	248	75	13	106	6.6
11 APR 1983	11:56:22	379	68	26	191	246	75	21	202	6.4
20 APR 1983	13:21:37	379	49	15	84	351	51	15	86	3.4
8 APR 1983	15:43:17	380	73	11	85	257	94	10	99	-.3
20 APR 1983	13:10:11	380	57	23	142	380	57	23	142	3.9
24 APR 1983	18:43:15	380	75	19	154	191	92	19	188	5.0
9 APR 1983	11:8:14	381	57	8	52	333	34	16	61	10.1
19 APR 1983	12:29:54	382	54	35	139	274	56	34	200	5.4
26 APR 1983	3:1:37	382	18	51	98	306	19	50	101	9.1
25 APR 1983	20:27:58	383	259	2	62	383	259	2	62	4.4
11 APR 1983	12:50:48	384	45	25	119	376	48	24	125	9.2
25 APR 1983	20:59:39	384	68	14	102	336	68	16	116	3.2
3 APR 1983	0:11:54	385	90	10	103	385	90	10	103	0.0
9 APR 1983	9:20:27	385	28	19	60	270	101	5	66	8.2
8 APR 1983	15:17:45	387	120	5	65	387	120	5	65	-.3
14 APR 1983	18:18:47	387	252	3	86	283	157	6	105	7.6
12 APR 1983	20:21:34	388	190	4	87	324	324	1	106	3.3
3 APR 1983	0:30:6	389	105	16	186	389	105	16	186	0.0
25 APR 1983	17:16:6	389	53	10	58	219	135	6	89	6.2
26 APR 1983	20:51:9	389	55	11	79	324	75	9	84	9.0
19 APR 1983	12:58:33	390	127	11	153	384	127	11	154	3.8
3 APR 1983	2:50:33	391	56	55	322	181	56	56	330	0.0
9 APR 1983	11:9:16	391	125	4	59	391	125	4	59	5.7
12 APR 1983	18:11:29	391	45	54	255	244	48	56	283	3.3
16 APR 1983	8:43:26	392	156	3	50	355	120	4	52	4.5
25 APR 1983	19:48:0	392	392	1	65	239	75	7	84	7.1
3 APR 1983	3:4:35	393	44	56	256	145	50	55	289	0.0
12 APR 1983	18:15:8	393	53	57	315	313	55	57	328	3.4
24 APR 1983	15:36:22	393	57	19	119	205	72	22	169	3.9
24 APR 1983	15:36:27	393	116	6	109	289	129	6	124	2.2
26 APR 1983	6:58:15	393	20	51	106	393	20	51	106	8.0
8 APR 1983	18:35:35	394	94	11	141	363	113	10	160	-.2
24 APR 1983	21:4:28	395	39	43	178	303	48	47	235	3.2
24 APR 1983	21:43:43	395	37	38	149	395	37	38	149	10.9
25 APR 1983	17:31:34	395	139	6	96	208	48	24	122	6.5

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
25 APR 1983	20:35:29	399	50	14	76	211	53	14	103	6.5
3 APR 1983	0:28:15	400	133	12	184	255	63	30	199	0.0
13 APR 1983	9:11:34	403	39	8	89	360	121	7	102	3.8
24 APR 1983	18:18:27	403	72	7	63	392	62	9	70	4.6
9 APR 1983	10:9:27	404	197	4	93	404	197	4	93	7.9
24 APR 1983	15:7:46	404	220	3	86	404	220	3	86	6.0
16 APR 1983	13:31:23	405	309	2	109	374	191	3	113	1.3
8 APR 1983	17:20:32	408	82	9	91	408	82	9	91	-.2
25 APR 1983	20:12:37	408	57	10	65	298	56	12	.73	2.2
13 APR 1983	6:17:45	409	125	14	199	404	130	14	202	3.4
11 APR 1983	12:51:22	410	349	2	85	410	349	2	85	10.1
9 APR 1983	9:22:10	411	26	45	121	325	40	34	146	6.3
9 APR 1983	10:8:56	411	47	23	134	411	47	23	134	8.8
11 APR 1983	12:23:51	412	108	11	129	247	85	21	192	7.2
11 APR 1983	12:49:31	412	122	4	73	227	54	14	89	5.2
12 APR 1983	20:26:9	412	149	4	77	315	315	1	91	5.0
21 APR 1983	9:21:24	413	40	18	83	413	40	18	83	6.5
24 APR 1983	16:17:44	414	81	11	102	414	81	11	102	3.6
7 APR 1983	15:13:31	415	163	3	90	379	56	10	96	0.0
11 APR 1983	8:55:57	416	197	5	122	416	197	5	122	1.7
13 APR 1983	13:20:51	416	56	29	175	416	56	29	175	2.1
3 APR 1983	2:51:53	417	54	56	320	265	54	57	321	0.0
11 APR 1983	10:1:13	417	30	33	106	417	30	33	106	2.9
24 APR 1983	15:29:2	417	66	32	223	254	61	49	312	7.3
3 APR 1983	0:12:30	418	59	16	106	341	64	15	106	0.0
12 APR 1983	16:12:1	418	61	20	133	208	57	25	148	6.3
24 APR 1983	19:10:13	418	170	3	79	289	39	25	116	7.8
12 APR 1983	14:15:38	419	41	31	135	240	38	35	142	6.7
21 APR 1983	9:1:20	419	70	26	191	419	70	26	192	.7
12 APR 1983	20:6:55	420	163	3	67	324	324	1	108	6.2
20 APR 1983	16:0:34	420	193	3	69	168	123	7	98	5.3
25 APR 1983	17:23:56	422	91	12	117	422	91	12	117	6.7
12 APR 1983	16:28:49	424	167	5	89	384	177	5	95	4.7
24 APR 1983	18:57:33	424	103	5	76	204	38	35	140	2.6
24 APR 1983	16:4:14	425	64	21	145	380	67	24	170	4.4
8 APR 1983	16:9:6	426	177	5	100	256	120	7	116	-.3
11 APR 1983	13:37:42	426	59	22	128	313	52	26	145	3.4
12 APR 1983	20:26:52	427	427	1	136	388	92	10	164	4.7
13 APR 1983	5:57:3	427	132	5	147	298	63	21	148	4.8
9 APR 1983	10:15:24	429	137	4	68	210	71	11	87	6.7
24 APR 1983	17:49:53	429	72	12	93	331	98	15	172	3.0
11 APR 1983	11:36:35	430	102	8	90	402	75	11	91	7.6
11 APR 1983	12:3:53	431	431	1	63	431	431	1	71	2.2
11 APR 1983	11:55:28	432	304	2	72	432	304	2	72	9.9
12 APR 1983	19:11:49	432	53	56	314	383	50	55	324	2.2
25 APR 1983	20:48:40	433	50	11	63	433	50	11	63	6.0
9 APR 1983	6:20:34	434	50	12	83	434	50	12	83	4.4
19 APR 1983	12:50:9	434	24	46	118	434	24	46	118	4.7
20 APR 1983	12:43:51	435	37	20	78	301	41	21	93	5.3
20 APR 1983	13:6:47	[illegible]	68	28	200	[illegible]	63	[illegible]	[illegible]	.4

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
24 APR 1983	18:57:17	436	45	36	169	338	45	36	171	3.1
3 APR 1983	1:54:2	437	50	54	282	437	50	54	282	0.0
24 APR 1983	21:36:16	437	138	9	140	368	163	8	144	8.6
8 APR 1983	0:57:41	438	40	36	152	372	43	35	160	0.0
12 APR 1983	20:1:44	438	161	4	127	428	169	4	129	2.4
9 APR 1983	11:8:37	439	98	7	76	341	157	4	77	6.7
21 APR 1983	10:50:9	440	236	3	80	374	200	4	98	8.5
19 APR 1983	12:36:34	441	29	35	107	347	37	30	126	3.4
12 APR 1983	18:10:47	443	56	57	335	443	56	57	335	6.2
19 APR 1983	13:10:18	443	66	17	131	437	76	28	225	6.9
8 APR 1983	16:48:52	444	102	7	90	157	63	14	95	-.3
24 APR 1983	22:2:35	444	26	32	96	396	21	41	99	3.6
8 APR 1983	18:22:20	445	445	1	58	331	331	1	71	-.3
24 APR 1983	15:29:13	445	58	25	152	445	58	25	152	5.5
14 APR 1983	15:59:56	446	125	5	70	421	159	5	95	7.7
9 APR 1983	10:26:35	447	175	3	58	391	31	20	67	8.8
8 APR 1983	17:22:9	448	96	19	203	440	98	19	207	-.2
11 APR 1983	9:38:31	449	104	11	127	331	76	29	236	8.5
2 APR 1983	23:23:4	451	109	9	108	168	63	20	137	0.0
9 APR 1983	8:16:36	451	59	16	109	451	59	16	109	3.8
12 APR 1983	20:29:20	452	146	4	107	315	299	2	109	4.6
8 APR 1983	18:33:37	453	101	13	149	450	104	13	153	-.3
12 APR 1983	16:18:26	453	162	9	167	453	162	9	167	5.9
20 APR 1983	12:55:17	453	78	8	71	453	78	8	71	1.2
24 APR 1983	15:51:44	453	53	20	180	439	47	25	195	3.3
24 APR 1983	15:5:22	455	139	17	264	340	143	17	272	5.6
9 APR 1983	10:14:55	456	62	9	134	456	62	9	134	7.1
19 APR 1983	13:17:15	456	102	7	83	328	146	8	130	7.5
9 APR 1983	11:11:11	457	133	4	68	225	66	18	136	6.7
8 APR 1983	18:33:13	458	102	10	122	395	81	14	128	-.2
9 APR 1983	10:30:8	461	167	3	81	311	178	4	129	3.7
12 APR 1983	20:27:4	461	269	2	111	461	269	2	111	2.6
9 APR 1983	10:28:12	462	165	6	124	448	72	17	132	9.3
11 APR 1983	8:55:8	462	107	13	159	386	78	20	176	8.1
14 APR 1983	18:14:14	468	468	1	58	337	247	2	66	1.7
9 APR 1983	10:37:15	469	76	13	120	457	47	25	126	7.4
11 APR 1983	12:1:54	469	57	26	156	446	55	27	162	3.2
13 APR 1983	9:12:1	470	52	21	116	453	49	23	119	4.0
8 APR 1983	14:29:56	471	98	8	85	471	98	8	85	.2
21 APR 1983	10:50:32	471	47	44	219	471	47	44	219	9.1
24 APR 1983	19:8:42	471	29	25	82	359	127	5	82	9.0
19 APR 1983	12:34:2	472	55	29	176	269	39	47	191	4.6
24 APR 1983	22:58:59	472	253	3	121	411	250	3	123	2.6
9 APR 1983	7:56:4	473	84	16	151	473	84	16	151	3.2
8 APR 1983	17:22:46	476	186	11	225	476	186	11	225	-.2
8 APR 1983	18:16:38	478	50	17	93	478	62	14	96	-.2
21 APR 1983	10:58:21	478	478	1	70	464	78	8	86	2.1
24 APR 1983	15:5:36	478	79	7	135	337	337	1	142	1.6
11 APR 1983	12:11:2	479	70	18	141	445	88	17	165	4.5
20 APR 1983	13:6:52	480	56	20	133	240	46	25	134	1.1

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8	APR	1983	17:41:40	481	111	9	110	481	111	9	110	-.3
24	APR	1983	18:47:45	481	62	40	263	481	62	40	263	4.7
8	APR	1983	7:40:44	482	36	55	206	476	40	55	231	7.2
24	APR	1983	21:0:18	482	22	37	88	359	19	45	89	2.6
19	APR	1983	13:3:44	483	37	43	168	483	37	43	168	5.3
9	APR	1983	9:39:29	484	63	26	178	438	231	8	228	3.1
20	APR	1983	13:6:27	485	102	20	214	481	104	22	240	1.4
24	APR	1983	11:32:11	485	90	14	141	450	80	15	152	6.0
24	APR	1983	15:0:10	485	135	8	119	431	122	9	120	2.8
9	APR	1983	10:8:19	486	117	5	68	295	85	9	87	9.5
25	APR	1983	18:14:34	486	84	7	68	409	65	10	87	1.9
11	APR	1983	14:12:15	488	66	20	159	486	76	19	176	2.2
24	APR	1983	19:9:39	489	261	3	92	266	60	17	108	9.4
24	APR	1983	22:4:37	489	30	47	150	489	30	47	150	9.3
8	APR	1983	18:33:3	490	345	2	82	490	345	2	82	-.2
24	APR	1983	21:41:17	490	40	19	91	366	39	16	159	7.7
24	APR	1983	22:59:12	490	28	47	142	212	34	44	169	3.6
25	APR	1983	18:32:14	492	61	10	70	481	75	9	79	4.7
8	APR	1983	16:4:53	494	166	4	84	494	166	4	84	-.3
24	APR	1983	16:16:27	494	57	33	207	486	75	33	266	7.7
24	APR	1983	15:0:16	495	89	14	138	495	89	14	138	1.4
7	APR	1983	15:1:19	496	153	7	138	496	153	7	138	0.0
9	APR	1983	9:20:39	496	35	33	123	439	28	45	131	8.1
11	APR	1983	9:42:52	496	259	3	125	496	259	3	125	8.6
19	APR	1983	12:42:37	496	80	16	168	496	80	16	168	2.2
11	APR	1983	12:1:20	497	111	17	202	495	119	15	203	2.8
9	APR	1983	10:27:9	499	99	8	90	345	53	19	109	6.7
11	APR	1983	12:12:15	499	117	6	80	473	171	4	80	3.1
11	APR	1983	8:55:45	501	324	3	120	398	130	9	132	3.0
12	APR	1983	19:40:12	504	166	4	108	338	80	8	118	3.7
14	APR	1983	16:18:45	504	68	11	84	373	187	4	91	4.7
8	APR	1983	17:23:4	507	128	5	82	460	121	6	91	-.2
20	APR	1983	13:32:31	508	74	20	156	508	74	20	156	4.2
24	APR	1983	21:3:48	508	78	19	179	508	78	19	179	7.9
25	APR	1983	20:59:31	508	141	9	134	492	188	7	139	4.3
3	APR	1983	4:35:11	509	80	21	183	413	77	25	219	0.0
11	APR	1983	13:0:22	510	43	16	82	510	43	16	82	9.1
12	APR	1983	19:58:25	511	62	21	138	511	62	21	138	3.8
14	APR	1983	16:2:30	512	259	4	125	256	69	29	209	4.3
26	APR	1983	7:23:52	513	204	4	103	513	204	4	103	8.9
8	APR	1983	18:22:33	514	91	8	91	327	56	29	173	-.2
24	APR	1983	19:9:51	515	422	2	120	410	387	2	121	7.9
8	APR	1983	7:43:39	516	270	4	306	430	61	50	321	6.3
12	APR	1983	14:44:44	517	96	26	267	517	96	26	267	6.4
21	APR	1983	9:17:11	517	78	18	162	511	82	17	162	3.0
21	APR	1983	9:9:58	518	333	3	128	286	111	11	158	3.5
9	APR	1983	18:0:10	519	57	29	182	255	65	29	202	-.2
11	APR	1983	12:20:12	522	197	3	87	353	91	8	96	5.9
21	APR	1983	10:45:29	522	69	10	79	408	113	16	207	9.5
11	APR	1983	11:58:49	523	100	9	104	247	99	11	114	9.9

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8 APR 1983	17:22:25	525	114	18	222	433	121	18	234	-.3
26 APR 1983	4:19:7	525	60	13	87	525	60	13	87	6.6
12 APR 1983	20:2:1	526	526	1	110	331	331	1	118	2.2
14 APR 1983	16:9:28	526	80	12	106	475	77	13	109	4.3
21 APR 1983	9:58:1	526	128	8	120	526	128	8	120	7.9
25 APR 1983	20:27:35	526	52	43	236	500	55	36	247	6.7
9 APR 1983	11:9:10	533	211	3	70	517	161	4	71	5.7
24 APR 1983	22:55:27	534	84	32	283	329	83	30	286	4.6
12 APR 1983	18:11:9	541	58	57	346	463	59	57	351	4.5
3 APR 1983	0:13:11	543	286	2	77	543	286	2	77	0.0
25 APR 1983	18:27:43	545	106	6	83	236	56	14	113	8.8
14 APR 1983	16:0:13	547	189	13	279	547	189	13	279	10.8
9 APR 1983	9:21:3	551	94	19	210	300	137	15	232	4.4
24 APR 1983	16:4:39	551	39	39	162	504	40	38	162	1.4
24 APR 1983	21:47:24	551	66	15	119	539	46	30	151	11.4
8 APR 1983	18:37:44	553	118	6	97	518	178	4	99	-.3
20 APR 1983	12:54:37	554	43	48	216	299	50	44	230	6.2
12 APR 1983	19:39:58	556	154	5	122	512	67	15	135	3.2
8 APR 1983	17:42:33	557	90	12	123	530	106	11	134	-.2
8 APR 1983	17:55:50	558	79	12	147	558	79	12	147	-.3
19 APR 1983	12:38:48	559	120	9	117	281	55	29	172	3.3
25 APR 1983	18:8:55	560	42	37	164	336	45	38	181	1.8
9 APR 1983	7:56:18	561	143	6	95	320	240	5	131	4.0
11 APR 1983	8:50:37	561	561	1	79	437	99	21	224	4.9
11 APR 1983	13:38:4	561	76	17	143	516	103	14	156	3.3
24 APR 1983	23:4:41	565	34	41	150	356	43	40	185	8.0
9 APR 1983	10:38:42	568	74	17	141	542	76	18	152	5.0
9 APR 1983	11:23:50	571	40	29	126	550	48	25	130	9.2
19 APR 1983	12:50:16	573	71	13	98	331	63	19	126	3.4
19 APR 1983	12:39:2	575	56	43	252	557	56	45	264	3.2
8 APR 1983	17:59:19	576	139	5	92	407	76	20	177	-.2
12 APR 1983	18:14:26	576	62	57	371	463	74	56	435	7.0
8 APR 1983	17:58:46	577	41	21	112	221	41	34	149	-.3
9 APR 1983	10:41:10	579	60	31	201	498	58	33	204	9.1
12 APR 1983	20:34:7	580	169	5	134	580	169	5	134	4.7
19 APR 1983	13:17:26	581	51	21	113	581	51	21	113	5.7
24 APR 1983	14:10:32	582	69	26	195	385	82	23	206	5.4
24 APR 1983	21:45:13	585	36	43	164	585	36	43	164	5.4
20 APR 1983	16:36:31	586	225	5	143	563	82	21	183	4.0
11 APR 1983	11:28:3	588	95	14	156	425	166	10	216	8.1
11 APR 1983	8:50:15	591	54	39	221	591	54	39	221	7.2
24 APR 1983	19:12:39	593	46	17	88	345	29	29	90	2.0
8 APR 1983	18:24:27	594	105	6	80	424	167	3	99	-.3
14 APR 1983	18:14:0	597	197	4	91	592	200	4	92	2.8
24 APR 1983	21:54:27	598	23	43	103	398	30	38	123	6.4
13 APR 1983	8:21:24	599	171	7	136	580	129	11	157	3.1
11 APR 1983	8:50:43	600	[illegible]	3	97	373	154	6	116	3.7
24 APR 1983	17:49:10	603	297	4	154	487	176	7	158	3.1
14 APR 1983	17:2:45	604	180	10	155	604	180	10	155	7.4
14 APR 1983	17:50:57	604	180	10	155	604	180	10	155	7.4

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
24 APR 1983	18:57:12	605	218	4	107	181	26	43	116	2.7
20 APR 1983	12:58:35	607	35	42	155	489	47	34	174	7.1
13 APR 1983	9:15:37	608	176	5	139	451	54	23	147	5.3
24 APR 1983	20:56:7	622	151	11	194	622	151	11	194	9.4
12 APR 1983	19:45:31	627	627	1	107	620	620	1	113	4.0
19 APR 1983	13:1:43	627	88	9	102	477	99	13	172	4.2
11 APR 1983	8:55:18	629	87	9	163	607	402	2	169	6.9
12 APR 1983	19:45:26	632	632	1	104	621	621	1	108	3.9
8 APR 1983	17:23:42	635	635	1	166	635	635	1	166	-.3
9 APR 1983	10:15:19	637	195	6	130	561	321	4	142	6.7
8 APR 1983	16:8:44	641	397	2	87	641	397	2	87	-.3
16 APR 1983	13:0:54	652	99	13	190	651	95	14	197	2.1
21 APR 1983	10:49:47	659	259	6	173	563	65	27	186	9.4
25 APR 1983	18:29:21	661	77	16	130	419	124	11	147	4.7
26 APR 1983	7:23:47	661	151	6	105	620	56	18	108	9.3
11 APR 1983	10:30:48	662	135	6	105	502	199	6	140	5.2
11 APR 1983	8:55:25	666	105	16	191	611	116	14	192	6.6
12 APR 1983	18:0:59	668	49	54	275	483	54	55	311	7.7
24 APR 1983	18:35:50	669	124	8	126	429	107	9	129	4.2
11 APR 1983	11:57:10	677	123	8	127	430	99	12	152	6.6
12 APR 1983	17:47:51	680	65	55	377	680	65	55	377	6.5
8 APR 1983	17:42:42	685	111	11	143	685	111	11	143	-.2
27 APR 1983	8:25:5	685	37	38	147	568	39	38	155	1.8
11 APR 1983	12:43:34	693	189	11	226	693	189	11	226	7.4
25 APR 1983	18:27:32	696	123	12	160	696	123	12	160	9.7
25 APR 1983	21:11:58	700	80	21	180	700	80	21	180	11.4
8 APR 1983	18:3:59	703	118	16	213	567	134	14	216	-.2
20 APR 1983	13:9:55	706	85	26	232	360	83	36	313	7.5
24 APR 1983	19:53:57	708	54	27	156	473	49	31	160	2.5
11 APR 1983	11:23:31	715	49	21	119	715	49	21	119	9.3
24 APR 1983	16:20:12	715	147	9	149	439	167	8	150	6.6
19 APR 1983	13:12:42	718	124	19	249	713	126	24	319	6.7
8 APR 1983	18:24:16	739	158	14	277	643	163	15	299	-.2
19 APR 1983	13:5:56	741	86	14	131	432	92	34	329	4.9
25 APR 1983	18:28:23	745	80	25	212	745	80	25	212	7.0
9 APR 1983	10:42:54	749	65	48	325	749	65	48	325	5.0
25 APR 1983	18:45:17	756	44	42	196	541	254	6	233	3.3
8 APR 1983	17:41:16	762	118	16	203	565	126	17	238	-.2
25 APR 1983	18:24:18	781	98	13	135	491	84	16	142	5.3
24 APR 1983	17:50:4	783	135	18	280	781	136	18	282	3.3
8 APR 1983	18:24:21	787	113	22	266	583	111	20	274	-.3
14 APR 1983	18:22:35	796	248	4	126	753	206	5	138	6.2
20 APR 1983	13:37:12	796	160	7	135	658	183	8	179	6.5
11 APR 1983	8:55:35	799	125	20	269	725	166	15	274	4.4
8 APR 1983	18:15:59	800	291	4	135	646	65	31	212	-.3
19 APR 1983	13:10:13	838	100	26	299	672	68	44	314	9.1
19 APR 1983	12:25:12	848	84	24	219	488	69	34	252	4.4
25 APR 1983	20:31:40	850	91	14	138	850	91	14	138	6.4
25 APR 1983	17:20:22	860	122	12	158	860	122	12	158	8.1
8 APR 1983	17:49:[illegible]	[illegible]	63	33	[illegible]	[illegible]	51	35	224	-.2

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
8 APR 1983	18:23:31	906	130	13	219	745	410	4	227	-.2
8 APR 1983	16:12:57	937	114	16	214	937	114	16	214	-.3
24 APR 1983	18:35:55	941	41	41	177	524	195	8	194	4.1
11 APR 1983	8:55:50	1006	180	10	219	740	323	5	234	2.5
24 APR 1983	18:38:32	1008	125	17	225	658	200	12	257	3.2
11 APR 1983	8:55:30	1011	208	14	318	642	229	10	393	5.6
14 APR 1983	19:8:0	1040	95	17	176	840	89	23	219	10.3
24 APR 1983	16:11:59	1141	173	27	491	1141	173	27	491	7.8
8 APR 1983	17:22:32	1235	76	33	269	1014	94	35	347	-.3
19 APR 1983	13:3:53	1243	305	7	239	548	100	28	294	5.6
20 APR 1983	13:6:18	1319	496	6	411	956	209	20	443	3.2
8 APR 1983	18:39:39	1327	325	7	260	1327	325	7	260	-.3
8 APR 1983	17:22:20	1640	261	9	254	1273	343	7	273	-.2

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 JAN 1984	17:30:54	139	70	7	51	119	45	14	66	4.2
12 JAN 1984	17:26:9	152	41	7	30	123	42	17	75	3.5
12 JAN 1984	16:52:25	154	42	13	57	131	44	13	60	1.8
12 JAN 1984	16:51:48	155	56	8	47	143	81	6	51	1.3
12 JAN 1984	16:33:9	173	32	42	141	164	32	43	144	5.0
12 JAN 1984	17:27:12	175	63	16	106	175	63	16	106	4.3
12 JAN 1984	17:28:38	177	42	14	62	77	26	23	63	6.8
12 JAN 1984	16:45:1	178	22	33	76	178	22	33	76	6.5
12 JAN 1984	16:27:44	184	45	15	71	171	49	26	134	7.2
12 JAN 1984	17:31:53	188	61	13	83	128	52	23	125	4.8
12 JAN 1984	17:24:44	193	27	26	74	165	47	21	104	1.7
12 JAN 1984	17:28:47	193	28	15	44	132	63	9	59	7.1
12 JAN 1984	16:32:41	194	28	35	103	164	30	34	107	5.3
12 JAN 1984	17:31:1	194	22	23	53	162	32	24	81	4.1
12 JAN 1984	17:25:15	195	59	14	87	174	49	22	113	3.2
12 JAN 1984	16:31:9	196	46	16	77	195	47	18	89	5.6
12 JAN 1984	16:51:40	196	22	39	90	172	27	44	125	1.0
13 JAN 1984	4:19:38	197	44	7	32	194	55	19	110	7.5
12 JAN 1984	16:32:7	198	106	6	67	173	75	19	149	5.9
12 JAN 1984	17:26:2	198	68	10	71	179	66	19	132	3.8
12 JAN 1984	16:48:30	199	30	25	79	103	22	42	97	6.7
12 JAN 1984	18:34:45	200	48	14	71	169	46	16	77	7.7
12 JAN 1984	16:29:59	202	63	12	79	202	63	12	79	7.4
12 JAN 1984	17:25:41	204	26	26	71	114	31	23	75	3.0
12 JAN 1984	18:48:1	204	31	21	68	149	31	44	143	7.0
12 JAN 1984	16:30:57	207	31	15	49	96	44	21	97	5.4
12 JAN 1984	16:26:24	208	23	31	75	208	23	31	75	7.2
12 JAN 1984	16:29:42	208	64	10	67	182	50	19	100	8.9
12 JAN 1984	18:34:6	209	49	11	57	151	47	25	123	8.0
12 JAN 1984	18:56:9	209	36	27	102	189	64	34	228	7.3
12 JAN 1984	17:32:30	212	50	15	79	194	65	13	89	4.0
13 JAN 1984	5:2:38	212	51	9	48	144	30	21	66	5.9
12 JAN 1984	17:31:41	213	76	13	104	159	54	24	136	4.4
12 JAN 1984	16:29:48	217	49	14	72	128	47	21	104	7.7
12 JAN 1984	17:30:21	217	45	22	104	217	45	22	104	4.2
12 JAN 1984	18:18:7	217	34	11	39	108	27	18	51	6.8
12 JAN 1984	18:46:50	217	33	28	97	196	35	29	106	6.6
12 JAN 1984	16:48:45	218	30	13	41	130	25	47	123	5.1
12 JAN 1984	16:31:35	219	64	19	128	219	64	19	128	5.5
12 JAN 1984	18:41:47	220	27	30	85	157	39	29	119	7.1
12 JAN 1984	23:29:35	221	36	12	45	100	24	32	81	7.2
12 JAN 1984	17:32:0	222	52	18	98	222	52	18	98	4.9
12 JAN 1984	16:25:25	224	40	14	59	224	40	14	59	6.9
12 JAN 1984	16:24:34	226	53	6	33	92	25	21	55	7.1
12 JAN 1984	17:28:55	227	61	11	70	227	61	11	70	6.4
12 JAN 1984	18:55:35	227	87	3	27	210	41	31	133	7.5
12 JAN 1984	17:31:9	228	37	27	105	135	38	29	116	4.5
12 JAN 1984	17:26:37	229	67	13	91	190	53	22	122	3.7
12 JAN 1984	16:25:30	230	22	24	55	230	22	24	55	7.4
12 JAN 1984	16:30:20	230	49	23	118	230	49	23	118	6.2

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 JAN 1984	17:29:47	231	55	12	69	145	51	23	123	5.2
12 JAN 1984	17:32:47	231	49	24	123	209	48	25	126	4.2
12 JAN 1984	19:1:26	231	90	19	179	205	99	18	187	6.7
12 JAN 1984	16:32:14	232	36	26	98	232	36	26	98	5.3
12 JAN 1984	16:31:57	234	56	18	106	195	68	17	121	5.3
12 JAN 1984	17:25:34	234	42	8	35	142	33	17	59	3.1
12 JAN 1984	17:26:27	234	152	2	32	111	56	15	88	4.3
12 JAN 1984	18:46:26	235	117	7	86	212	53	17	95	6.6
12 JAN 1984	18:49:18	235	23	28	68	164	32	28	94	6.8
12 JAN 1984	18:53:46	237	62	9	59	217	57	10	60	6.3
12 JAN 1984	16:31:40	238	46	20	97	167	55	22	127	5.6
12 JAN 1984	18:28:48	238	38	12	48	192	21	27	59	7.8
12 JAN 1984	18:39:10	238	74	9	70	133	40	29	122	6.6
12 JAN 1984	17:30:11	239	46	17	82	130	52	19	104	4.4
12 JAN 1984	18:49:12	239	46	18	87	232	74	13	101	7.0
12 JAN 1984	18:54:34	240	106	6	67	130	33	20	69	7.3
12 JAN 1984	19:36:12	241	51	27	144	241	51	27	144	8.0
12 JAN 1984	18:41:14	242	69	15	109	242	69	15	109	6.6
12 JAN 1984	16:30:52	244	49	17	87	186	62	17	111	5.2
12 JAN 1984	16:48:19	244	29	35	106	134	25	49	129	8.1
12 JAN 1984	18:46:16	244	58	22	134	244	58	22	134	6.5
12 JAN 1984	18:53:7	244	51	8	43	101	29	41	125	5.8
12 JAN 1984	18:59:43	244	48	15	76	170	34	30	107	6.6
12 JAN 1984	18:58:18	247	44	15	69	180	49	21	108	6.2
12 JAN 1984	16:52:10	248	90	13	123	248	90	13	123	2.2
12 JAN 1984	17:26:53	248	94	3	30	129	42	21	93	4.4
12 JAN 1984	18:21:4	248	74	5	39	233	33	19	66	7.6
12 JAN 1984	17:32:19	249	45	19	90	249	45	19	90	4.2
12 JAN 1984	18:50:41	250	51	29	155	197	51	34	182	7.2
12 JAN 1984	16:32:26	252	38	23	92	181	63	16	106	4.9
12 JAN 1984	18:45:17	252	93	6	59	161	49	22	113	7.2
12 JAN 1984	18:58:2	253	47	21	104	164	52	22	120	6.5
12 JAN 1984	16:27:28	254	47	20	99	220	52	20	109	7.2
12 JAN 1984	17:27:53	255	105	3	33	141	45	9	42	5.2
12 JAN 1984	18:40:42	255	62	17	111	228	39	30	123	6.5
12 JAN 1984	18:33:43	256	67	26	183	256	67	26	183	7.4
12 JAN 1984	18:47:37	257	80	7	59	257	80	7	59	7.6
12 JAN 1984	18:50:56	257	67	6	42	216	88	7	65	7.1
12 JAN 1984	18:59:49	258	59	23	142	258	59	23	142	6.3
12 JAN 1984	18:51:50	259	59	16	99	180	54	18	102	7.0
12 JAN 1984	17:29:22	260	80	7	59	259	89	7	65	5.3
12 JAN 1984	17:33:13	260	54	11	62	187	41	16	69	5.4
12 JAN 1984	23:26:6	260	75	13	102	223	90	11	104	4.8
13 JAN 1984	3:37:29	260	127	3	40	185	62	19	124	6.7
12 JAN 1984	18:20:21	262	27	25	71	160	22	40	92	5.8
12 JAN 1984	16:25:6	263	48	8	40	85	22	35	81	8.0
12 JAN 1984	17:31:30	263	138	4	58	130	48	19	96	4.6
12 JAN 1984	17:25:56	264	48	19	96	164	56	24	141	4.0
13 JAN 1984	1:39:7	264	42	36	159	264	42	36	159	9.3
12 JAN 1984	17:31:48	265	61	20	128	207	59	22	136	4.7

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 JAN 1984	18:51:58	266	73	4	31	227	48	32	161	7.0
13 JAN 1984	6:40:16	266	36	20	76	266	36	20	76	6.4
12 JAN 1984	18:45:39	268	39	9	37	248	37	19	74	7.2
12 JAN 1984	19:0:18	268	55	18	104	268	55	18	104	6.3
12 JAN 1984	19:0:32	268	44	29	134	179	79	20	166	6.4
13 JAN 1984	0:22:51	269	25	37	97	269	25	37	97	8.3
12 JAN 1984	18:21:49	271	54	12	68	133	34	39	139	7.4
12 JAN 1984	19:1:14	271	23	31	75	226	27	33	93	5.9
13 JAN 1984	5:21:53	272	35	27	99	272	35	27	99	5.4
12 JAN 1984	16:26:55	273	98	4	41	187	53	15	83	6.6
12 JAN 1984	17:30:39	275	49	14	72	129	41	20	86	4.7
13 JAN 1984	4:56:10	277	31	22	72	274	55	22	127	8.5
12 JAN 1984	18:46:6	278	46	20	97	278	46	20	97	6.8
13 JAN 1984	1:3:8	278	41	14	60	152	46	27	130	8.1
13 JAN 1984	2:32:37	278	35	16	59	239	55	12	69	6.9
13 JAN 1984	1:3:44	280	66	7	48	183	49	22	113	7.9
12 JAN 1984	18:23:37	282	86	4	36	185	66	15	104	8.1
12 JAN 1984	18:43:36	282	118	3	37	124	24	26	65	7.4
13 JAN 1984	1:40:32	282	80	9	76	205	74	16	124	8.2
12 JAN 1984	16:32:32	283	40	25	105	179	51	25	134	5.0
12 JAN 1984	18:55:40	283	47	30	148	283	47	30	148	7.5
12 JAN 1984	19:1:32	283	69	9	65	154	43	23	104	6.5
13 JAN 1984	5:19:34	283	37	31	120	283	37	31	120	8.3
13 JAN 1984	6:59:26	286	33	13	45	253	30	18	57	6.7
12 JAN 1984	18:15:25	288	288	1	30	279	40	36	151	6.4
12 JAN 1984	18:46:57	288	124	13	169	223	69	24	174	6.5
12 JAN 1984	17:32:11	289	65	16	109	289	65	16	109	4.4
12 JAN 1984	18:43:19	289	43	15	68	289	43	15	68	7.5
12 JAN 1984	23:41:24	289	93	7	68	169	39	25	102	7.0
12 JAN 1984	16:44:45	291	201	2	42	174	27	20	57	7.7
12 JAN 1984	18:39:39	292	40	13	55	186	67	20	141	6.4
12 JAN 1984	18:52:4	292	116	5	61	292	116	5	61	6.7
12 JAN 1984	18:57:42	292	51	17	91	161	42	30	132	6.7
13 JAN 1984	0:1:45	292	56	27	159	292	56	27	159	8.3
13 JAN 1984	0:42:44	292	75	9	71	195	46	19	92	7.7
13 JAN 1984	1:20:13	292	38	24	96	292	38	24	96	8.5
12 JAN 1984	16:26:3	293	46	14	68	155	53	23	128	6.7
13 JAN 1984	1:56:3	293	65	11	75	203	67	12	84	4.3
12 JAN 1984	18:47:55	294	64	10	67	133	51	21	112	7.1
12 JAN 1984	23:40:7	294	130	5	68	138	41	19	82	6.7
13 JAN 1984	0:58:54	295	31	31	101	169	38	34	136	8.8
13 JAN 1984	2:2:48	295	64	7	47	171	41	21	90	8.3
13 JAN 1984	2:35:45	295	72	11	83	262	91	10	95	7.1
12 JAN 1984	23:42:4	296	56	12	71	112	30	30	94	9.8
12 JAN 1984	19:44:12	297	297	1	31	153	40	18	76	7.6
12 JAN 1984	21:26:43	298	84	6	53	204	55	18	104	6.0
13 JAN 1984	2:15:44	298	48	7	35	267	53	22	122	9.3
12 JAN 1984	18:49:30	299	66	9	62	170	49	22	113	6.9
12 JAN 1984	18:53:1	300	20	40	84	300	20	40	84	6.1
12 JAN 1984	18:54:12	301	77	12	97	206	41	27	116	7.1

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 JAN 1984	17:35:3	302	49	11	57	130	36	16	60	5.8
13 JAN 1984	4:58:50	302	77	7	57	302	77	7	57	5.5
12 JAN 1984	18:27:53	303	64	9	60	303	64	9	60	9.6
12 JAN 1984	18:35:1	303	56	15	88	209	44	20	92	7.5
13 JAN 1984	5:8:7	303	29	28	85	303	29	28	85	7.8
12 JAN 1984	18:21:24	304	31	29	94	304	31	29	94	7.3
12 JAN 1984	19:2:40	305	50	36	189	305	50	36	189	7.5
13 JAN 1984	2:18:11	305	31	22	72	226	43	30	135	8.3
12 JAN 1984	16:44:55	306	306	1	32	248	55	6	35	6.4
12 JAN 1984	18:56:16	306	44	21	97	203	75	22	173	6.9
12 JAN 1984	21:9:17	306	60	9	57	190	36	18	68	7.1
13 JAN 1984	2:27:18	308	93	11	107	308	93	11	107	7.8
12 JAN 1984	18:19:14	309	46	12	58	183	48	13	65	6.2
12 JAN 1984	18:32:28	309	22	28	65	87	26	29	79	7.8
12 JAN 1984	18:48:33	309	39	24	98	174	28	34	100	7.2
12 JAN 1984	19:22:45	310	74	9	70	274	33	28	97	6.0
12 JAN 1984	19:27:48	311	85	12	107	223	60	18	113	8.3
12 JAN 1984	19:18:33	312	41	13	56	123	47	18	89	7.6
13 JAN 1984	2:33:7	313	39	11	45	240	69	22	159	7.2
12 JAN 1984	17:25:27	314	70	12	88	264	27	35	99	2.4
13 JAN 1984	1:46:2	314	71	11	82	314	71	11	82	7.0
13 JAN 1984	2:31:35	316	50	18	94	292	68	14	100	7.6
13 JAN 1984	4:58:2	317	42	21	93	202	39	24	98	6.2
12 JAN 1984	21:28:55	319	74	10	78	228	65	13	89	2.6
13 JAN 1984	1:38:5	320	33	20	69	177	69	20	145	7.6
12 JAN 1984	18:33:16	321	41	9	39	160	37	42	163	8.6
13 JAN 1984	1:27:0	321	69	12	87	193	67	14	98	8.5
12 JAN 1984	18:58:54	322	140	4	59	221	68	17	121	6.7
12 JAN 1984	16:25:36	323	51	8	43	314	62	7	46	6.4
13 JAN 1984	5:40:31	323	44	25	115	162	54	31	176	8.6
13 JAN 1984	6:57:8	323	70	6	44	323	70	6	44	7.5
12 JAN 1984	18:35:39	325	53	14	78	325	53	14	78	7.6
12 JAN 1984	18:33:33	326	75	9	71	234	52	31	169	8.3
12 JAN 1984	18:43:55	326	39	32	131	326	39	32	131	7.2
13 JAN 1984	1:47:23	326	40	17	71	314	108	10	113	6.7
12 JAN 1984	16:48:2	328	47	25	123	97	27	44	125	10.4
13 JAN 1984	1:38:30	329	329	1	35	172	39	18	74	7.0
13 JAN 1984	3:54:29	329	59	14	87	329	59	14	87	6.3
13 JAN 1984	6:56:25	329	44	14	65	292	29	27	82	9.1
12 JAN 1984	19:1:4	330	87	8	73	140	38	20	80	6.0
13 JAN 1984	1:38:20	330	73	8	61	221	112	11	129	6.9
12 JAN 1984	18:46:40	332	60	6	38	192	29	19	58	6.6
12 JAN 1984	18:44:10	334	48	31	156	268	83	22	192	7.4
13 JAN 1984	2:29:47	336	111	7	82	336	111	7	82	7.5
13 JAN 1984	2:37:24	336	53	11	61	336	53	11	61	1.2
12 JAN 1984	18:20:41	339	78	5	41	177	28	21	62	7.8
13 JAN 1984	1:50:43	339	70	9	66	315	49	32	165	7.7
13 JAN 1984	4:47:58	339	339	1	36	179	35	18	66	7.2
13 JAN 1984	5:42:16	340	68	16	114	243	61	18	115	2.4
12 JAN 1984	18:56:43	341	58	14	65	247	42	23	101	6.4

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
12 JAN 1984	18:59:4	341	70	14	103	182	75	18	142	6.4
12 JAN 1984	20:48:26	341	51	20	107	269	41	25	108	6.7
13 JAN 1984	2:2:42	341	27	25	71	114	50	17	89	8.3
13 JAN 1984	4:45:55	341	73	9	69	140	27	40	113	9.2
13 JAN 1984	1:46:33	342	51	14	75	308	44	19	88	6.4
13 JAN 1984	2:32:48	342	89	5	47	141	35	25	92	7.2
13 JAN 1984	2:31:21	343	81	6	51	207	58	19	116	8.0
13 JAN 1984	3:45:29	343	51	12	64	343	51	12	64	6.6
13 JAN 1984	3:49:24	343	45	24	113	343	45	24	113	6.7
12 JAN 1984	19:36:35	344	22	33	76	215	54	18	102	6.3
13 JAN 1984	5:11:11	345	43	17	77	161	33	32	111	8.1
12 JAN 1984	18:49:42	347	48	46	232	268	52	44	240	7.1
12 JAN 1984	18:47:12	348	29	19	58	348	29	19	58	6.4
13 JAN 1984	1:4:54	348	38	16	64	245	43	21	95	8.6
13 JAN 1984	0:43:30	349	59	12	74	141	27	30	85	7.9
13 JAN 1984	2:33:22	349	65	13	89	166	34	35	125	6.6
13 JAN 1984	5:10:43	349	78	7	57	232	75	11	87	7.3
13 JAN 1984	1:25:38	350	62	10	65	198	57	12	72	8.4
13 JAN 1984	2:25:14	351	100	9	94	276	27	34	96	7.8
13 JAN 1984	5:17:29	352	58	16	97	352	58	16	97	8.6
13 JAN 1984	2:22:21	353	49	15	77	241	43	28	126	7.0
12 JAN 1984	18:48:15	355	34	15	54	172	40	21	88	6.9
13 JAN 1984	2:25:56	355	170	3	54	183	56	11	65	6.4
13 JAN 1984	1:25:21	356	54	8	45	291	57	14	84	8.6
13 JAN 1984	5:40:12	356	32	21	71	338	66	30	208	9.5
13-JAN 1984	1:37:45	357	42	23	101	264	59	23	142	8.6
13 JAN 1984	2:20:48	358	42	19	84	358	42	19	84	6.9
13 JAN 1984	5:23:46	358	358	1	38	198	49	22	113	5.3
13 JAN 1984	0:41:46	359	126	3	40	314	79	19	157	7.5
13 JAN 1984	2:26:59	359	73	14	107	359	73	14	107	7.2
12 JAN 1984	18:55:16	360	37	28	109	180	44	30	138	7.9
13 JAN 1984	1:50:35	360	50	30	157	178	51	34	182	8.6
13 JAN 1984	1:16:43	362	39	20	82	304	48	17	66	7.3
13 JAN 1984	1:54:2	362	110	10	115	346	75	15	118	5.2
12 JAN 1984	23:21:34	363	66	17	118	303	80	16	134	4.1
13 JAN 1984	5:40:48	363	48	31	156	189	42	41	181	8.4
12 JAN 1984	18:51:42	364	48	18	91	313	54	16	91	6.8
13 JAN 1984	0:2:34	365	187	2	39	253	92	10	97	7.2
13 JAN 1984	2:34:53	366	108	6	68	254	63	13	86	6.5
12 JAN 1984	18:50:18	367	161	3	51	203	64	17	114	7.0
12 JAN 1984	17:28:23	368	35	23	84	335	35	24	88	7.0
12 JAN 1984	18:44:36	371	49	39	200	371	49	39	200	7.6
12 JAN 1984	23:26:30	371	52	17	93	327	76	16	128	7.9
13 JAN 1984	2:30:49	376	149	3	47	148	51	23	123	7.9
12 JAN 1984	23:19:41	378	105	9	99	256	104	13	142	4.2
13 JAN 1984	3:51:55	378	93	5	49	204	29	32	97	6.4
13 JAN 1984	4:52:56	378	50	15	79	172	32	36	121	6.8
12 JAN 1984	21:27:17	379	65	16	109	210	42	27	119	4.7
13 JAN 1984	1:46:21	379	38	22	88	216	45	19	90	7.4
12 JAN 1984	20:42:55	380	47	14	69	201	22	39	90	9.2

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
13 JAN 1984	3:55:33	380	36	16	60	116	30	25	79	7.2
13 JAN 1984	2:21:50	381	52	12	65	262	43	32	144	6.7
13 JAN 1984	1:41:52	382	133	5	70	376	86	13	117	8.5
12 JAN 1984	18:16:54	384	33	29	100	384	33	29	100	6.7
13 JAN 1984	6:39:2	385	45	22	104	385	45	22	104	4.2
12 JAN 1984	19:37:47	387	56	20	118	387	56	20	118	7.0
13 JAN 1984	1:58:47	387	143	5	75	274	104	13	142	7.5
13 JAN 1984	2:25:24	389	73	8	61	151	57	13	78	7.6
12 JAN 1984	22:40:8	390	53	18	100	266	55	21	121	5.3
12 JAN 1984	18:44:19	391	47	21	104	207	38	38	151	7.7
12 JAN 1984	19:1:26	391	47	20	99	264	59	33	204	6.4
13 JAN 1984	4:40:18	394	80	12	101	314	71	20	149	5.8
12 JAN 1984	21:10:34	396	89	17	159	341	82	19	163	7.0
13 JAN 1984	2:24:19	406	77	15	121	327	118	14	173	7.2
13 JAN 1984	2:26:15	406	56	9	53	184	40	17	71	7.1
12 JAN 1984	18:56:58	408	61	19	122	119	43	28	126	6.6
13 JAN 1984	0:39:0	409	99	6	62	409	99	6	62	7.9
13 JAN 1984	2:34:32	413	87	10	91	240	63	29	192	7.1
13 JAN 1984	4:40:5	413	99	6	62	239	51	30	161	5.9
12 JAN 1984	18:52:33	414	165	7	121	310	76	19	151	6.2
12 JAN 1984	23:29:57	414	36	32	121	414	36	32	121	7.1
13 JAN 1984	1:44:53	415	243	2	51	415	243	2	51	7.2
13 JAN 1984	5:21:6	416	51	22	118	416	51	22	118	7.7
13 JAN 1984	2:34:4	421	62	39	254	421	62	39	254	6.5
13 JAN 1984	5:24:12	423	423	1	44	275	73	21	161	5.4
13 JAN 1984	0:17:7	428	104	5	55	145	25	24	63	8.3
13 JAN 1984	1:31:55	431	93	13	127	133	54	24	136	9.1
13 JAN 1984	1:42:45	432	432	1	45	267	47	17	84	7.7
12 JAN 1984	18:59:25	438	66	12	83	438	66	12	83	6.0
13 JAN 1984	6:36:8	439	82	9	77	247	59	21	130	4.4
13 JAN 1984	2:35:56	440	56	30	176	334	75	34	268	6.7
12 JAN 1984	20:46:56	441	441	1	46	260	62	15	98	7.7
13 JAN 1984	6:36:44	444	444	1	47	424	78	15	123	4.1
13 JAN 1984	2:31:47	460	52	23	125	460	52	23	125	7.7
13 JAN 1984	0:41:53	461	33	25	67	126	28	34	100	7.9
12 JAN 1984	19:18:47	464	53	15	83	279	42	20	88	6.0
13 JAN 1984	1:43:14	467	63	13	86	275	55	20	115	8.0
13 JAN 1984	5:12:43	473	188	5	99	356	119	8	100	7.9
12 JAN 1984	19:39:3	484	57	43	257	484	57	43	257	9.8
13 JAN 1984	0:57:54	484	40	20	84	313	66	18	125	6.3
13 JAN 1984	4:54:50	489	45	34	161	489	45	34	161	9.0
13 JAN 1984	0:54:15	494	68	10	71	406	57	17	102	5.2
13 JAN 1984	0:48:32	496	496	1	52	433	53	22	122	5.5
13 JAN 1984	0:40:11	497	67	9	63	216	38	27	108	7.5
13 JAN 1984	1:41:3	500	170	4	71	265	67	19	134	7.6
13 JAN 1984	0:58:5	506	58	22	134	506	58	22	134	6.0
13 JAN 1984	4:36:32	514	52	27	147	514	52	27	147	7.7
13 JAN 1984	0:54:42	528	58	20	122	390	62	19	124	3.8
13 JAN 1984	0:58:34	537	48	27	136	492	50	28	147	5.7
13 JAN 1984	0:40:48	550	32	22	74	219	44	37	171	7.5

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DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
13 JAN 1984	0:56:29	550	55	19	110	505	49	24	123	6.0
13 JAN 1984	2:14:8	553	553	1	58	87	26	29	79	8.2
13 JAN 1984	0:54:37	564	71	20	149	491	60	24	151	5.1
13 JAN 1984	2:17:35	564	96	8	81	564	96	8	81	9.0
13 JAN 1984	5:9:44	580	580	1	61	278	70	12	88	8.8
13 JAN 1984	0:55:48	582	59	17	105	170	62	18	117	3.5
13 JAN 1984	2:21:0	588	37	29	113	528	31	37	120	6.6
13 JAN 1984	5:21:27	589	91	11	105	447	60	17	107	6.1
13 JAN 1984	5:20:51	594	57	23	138	594	57	23	138	9.3

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
18 NOV 1984	15:8:27	87	11	23	27	87	11	23	27	0.0
18 NOV 1984	15:15:28	90	31	6	20	36	12	17	21	0.0
18 NOV 1984	15:0:9	91	15	10	16	24	9	34	32	0.0
27 NOV 1984	15:20:46	93	15	14	22	93	15	14	22	2.1
1 DEC 1984	13:55:4	104	104	1	11	41	7	42	31	1.8
1 DEC 1984	13:53:32	109	13	16	22	109	13	16	22	2.4
1 DEC 1984	13:20:10	110	64	2	13	60	15	26	41	2.4
1 DEC 1984	13:49:38	111	111	1	12	55	7	16	12	0.0
1 DEC 1984	13:50:20	117	20	12	25	97	11	25	29	0.0
18 NOV 1984	13:7:39	126	31	5	16	81	20	13	27	0.0
1 DEC 1984	13:54:48	127	20	14	29	105	13	26	35	2.3
27 NOV 1984	17:14:23	130	130	1	14	37	9	31	29	2.1
18 NOV 1984	13:53:10	134	12	21	26	128	15	17	27	0.0
18 NOV 1984	10:32:31	135	35	5	18	87	21	11	24	0.0
1 DEC 1984	13:39:8	135	34	9	32	61	12	34	43	2.3
18 NOV 1984	10:39:58	136	24	13	33	62	14	25	37	0.0
29 NOV 1984	19:59:7	139	26	7	19	25	6	34	21	0.0
1 DEC 1984	15:13:59	139	53	3	17	94	25	8	21	1.3
1 DEC 1984	13:6:51	140	33	7	24	63	9	40	38	4.6
18 NOV 1984	10:41:22	145	145	1	15	117	61	9	58	0.0
1 DEC 1984	13:52:11	145	78	2	16	142	14	13	19	0.0
1 DEC 1984	14:24:14	146	21	9	20	115	79	4	33	3.0
18 NOV 1984	10:35:25	147	44	14	65	137	45	14	66	0.0
1 DEC 1984	13:36:4	149	15	13	20	61	13	32	44	3.1
18 NOV 1984	13:1:33	150	14	15	22	150	14	15	22	0.0
18 NOV 1984	10:39:10	152	52	5	27	147	36	27	102	0.0
1 DEC 1984	13:36:51	156	43	4	18	79	16	20	34	1.4
1 DEC 1984	13:36:18	158	70	3	22	64	10	40	42	1.9
28 NOV 1984	5:58:52	162	39	9	37	114	14	40	59	2.4
1 DEC 1984	15:2:55	162	48	5	25	83	15	31	49	2.6
18 NOV 1984	15:6:11	165	14	28	41	165	14	28	41	0.0
27 NOV 1984	18:32:31	165	36	7	26	102	20	28	59	3.3
28 NOV 1984	3:42:40	170	36	5	19	39	10	35	37	2.7
1 DEC 1984	13:37:17	175	22	10	23	175	22	10	23	1.1
27 NOV 1984	20:10:16	182	95	2	20	152	18	29	55	2.4
1 DEC 1984	13:40:3	182	76	3	24	111	16	32	54	2.9
28 NOV 1984	4:29:31	186	78	5	41	155	32	18	60	0.0
18 NOV 1984	14:52:0	187	43	7	32	71	9	36	34	0.0
19 NOV 1984	12:26:32	187	22	28	65	187	22	28	65	0.0
18 NOV 1984	14:53:46	189	18	14	26	70	10	36	38	0.0
18 NOV 1984	10:38:37	190	46	7	34	46	12	31	39	0.0
18 NOV 1984	13:58:34	195	64	3	26	162	28	11	32	0.0
27 NOV 1984	18:49:58	195	44	6	28	136	38	8	32	0.0
1 DEC 1984	15:12:15	198	68	6	43	140	30	14	44	2.7
1 DEC 1984	13:50:30	199	199	1	21	184	24	9	23	0.0
27 NOV 1984	20:1:45	200	27	16	45	87	25	18	47	0.0
28 NOV 1984	4:2:17	201	19	40	80	184	22	36	63	3.5
27 NOV 1984	20:10:37	202	202	1	21	173	17	14	25	0.0
18 NOV 1984	14:0:11	203	51	14	75	193	45	16	76	0.0
28 NOV 1984	4:29:0	203	203	1	21	156	33	18	62	1.7

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
29 NOV 1984	19:46:50	203	22	38	88	203	22	38	88	0.0
29 NOV 1984	18:44:0	206	22	37	85	142	64	14	94	3.0
1 DEC 1984	14:14:22	210	74	3	23	70	13	37	50	2.9
28 NOV 1984	3:7:12	212	25	29	76	177	27	30	65	2.1
18 NOV 1984	13:46:38	224	28	14	41	106	13	42	57	0.0
29 NOV 1984	18:32:54	224	28	38	112	224	29	38	116	3.8
18 NOV 1984	10:34:7	226	64	12	81	214	75	11	87	0.0
28 NOV 1984	5:40:53	226	36	19	72	184	35	25	92	3.1
29 NOV 1984	20:1:40	227	67	4	28	69	13	29	40	4.5
1 DEC 1984	15:13:51	228	38	9	36	228	38	9	36	1.9
18 NOV 1984	14:53:23	229	44	10	46	229	44	10	46	0.0
28 NOV 1984	6:0:16	231	46	19	92	231	46	19	92	2.7
18 NOV 1984	13:49:12	233	62	6	39	179	42	20	88	0.0
18 NOV 1984	13:17:50	234	24	25	63	179	41	16	69	0.0
28 NOV 1984	0:34:20	234	21	18	40	234	21	18	40	1.8
27 NOV 1984	21:4:59	235	64	4	27	235	64	4	27	0.0
28 NOV 1984	5:59:58	235	38	29	116	184	44	30	138	2.7
18 NOV 1984	13:11:7	236	35	11	40	77	12	41	52	0.0
29 NOV 1984	19:54:9	236	26	13	35	236	26	13	35	1.0
28 NOV 1984	16:15:11	237	36	24	91	237	36	24	91	4.2
27 NOV 1984	22:17:1	238	192	2	40	201	40	16	67	0.0
18 NOV 1984	13:7:26	242	152	3	48	105	15	33	52	0.0
28 NOV 1984	3:59:43	245	17	33	59	245	17	33	59	3.0
29 NOV 1984	19:49:2	246	31	21	68	167	33	44	152	4.6
27 NOV 1984	21:39:0	247	41	8	34	247	41	8	34	1.6
28 NOV 1984	9:14:10	248	140	2	29	109	20	31	65	2.8
29 NOV 1984	19:8:1	248	43	10	45	248	43	10	45	3.3
18 NOV 1984	13:49:27	249	20	17	36	177	64	8	54	0.0
1 DEC 1984	15:14:9	249	52	6	33	237	17	21	37	1.1
18 NOV 1984	10:39:50	250	68	16	114	238	81	15	127	0.0
28 NOV 1984	3:40:29	250	250	1	26	156	48	22	111	2.5
29 NOV 1984	19:7:24	252	35	33	121	236	36	34	128	3.3
29 NOV 1984	19:32:6	253	40	12	50	63	15	38	60	3.9
1 DEC 1984	15:13:45	253	35	24	88	182	24	39	98	2.1
18 NOV 1984	14:49:36	254	60	5	31	214	78	4	33	0.0
29 NOV 1984	19:11:45	254	31	42	137	254	31	42	137	3.9
1 DEC 1984	14:14:41	254	31	12	39	197	14	38	56	2.6
28 NOV 1984	3:20:38	257	29	20	61	253	33	21	73	3.1
28 NOV 1984	7:49:21	257	27	35	99	257	27	35	99	1.8
27 NOV 1984	20:19:31	258	258	1	27	178	34	15	54	2.3
27 NOV 1984	20:32:9	259	50	10	52	113	20	42	88	0.0
18 NOV 1984	10:44:23	260	87	3	27	135	20	24	50	0.0
19 NOV 1984	12:21:15	261	48	20	101	250	51	19	102	0.0
28 NOV 1984	16:14:42	262	42	8	35	262	42	8	35	0.0
28 NOV 1984	16:14:28	264	38	12	48	193	29	18	55	4.5
18 NOV 1984	13:43:16	265	48	10	50	232	99	5	52	0.0
28 NOV 1984	3:53:47	265	26	34	93	128	26	38	104	3.2
29 NOV 1984	20:2:12	265	40	31	130	186	46	30	145	3.5
28 NOV 1984	13:16:38	265	58	12	73	253	91	11	105	3.5
28 NOV 1984	16:1:14	266	36	15	57	62	14	45	66	2.6

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
27 NOV 1984	22:36:27	267	30	22	69	263	28	24	71	3.0
18 NOV 1984	14:50:58	268	27	17	48	267	58	11	67	0.0
18 NOV 1984	13:1:51	269	64	6	40	131	15	40	63	0.0
28 NOV 1984	16:1:2	269	49	11	57	269	49	11	57	2.9
18 NOV 1984	14:54:1	270	29	30	91	179	40	27	113	0.0
18 NOV 1984	13:10:51	271	25	31	81	248	27	32	91	0.0
19 NOV 1984	14:6:30	272	26	17	46	178	19	30	60	0.0
27 NOV 1984	20:1:50	272	55	7	40	214	48	9	45	0.0
28 NOV 1984	16:14:59	274	99	11	114	217	36	42	159	0.0
1 DEC 1984	16:51:29	274	49	12	62	234	41	17	73	3.3
29 NOV 1984	10:15:16	275	75	20	157	275	75	20	157	3.6
18 NOV 1984	10:42:3	277	76	4	32	108	34	22	78	0.0
29 NOV 1984	19:59:58	277	60	6	38	277	60	6	38	2.2
28 NOV 1984	8:39:1	278	72	11	83	223	31	26	85	2.3
29 NOV 1984	19:29:1	278	51	22	118	240	82	14	120	2.1
29 NOV 1984	20:31:36	279	71	11	82	129	24	39	98	0.0
29 NOV 1984	20:25:53	282	106	5	55	282	106	5	55	3.7
18 NOV 1984	13:48:4	283	36	10	38	89	25	19	50	0.0
28 NOV 1984	22:23:11	289	36	27	102	231	51	30	161	2.6
29 NOV 1984	20:4:38	290	67	20	141	290	67	20	141	3.5
29 NOV 1984	20:38:59	291	168	2	35	117	15	42	66	3.4
18 NOV 1984	13:1:43	292	36	17	64	144	28	35	103	0.0
28 NOV 1984	3:5:57	292	31	33	107	292	31	33	107	3.0
29 NOV 1984	19:43:31	293	32	36	121	293	32	36	121	2.7
29 NOV 1984	18:48:54	294	34	39	139	294	34	39	139	3.6
18 NOV 1984	13:11:18	297	31	24	78	202	38	29	116	0.0
29 NOV 1984	20:3:40	297	34	12	43	293	36	12	45	1.4
29 NOV 1984	10:17:56	298	53	23	128	277	67	19	134	2.9
28 NOV 1984	6:0:6	299	30	21	66	172	26	37	101	2.7
18 NOV 1984	13:46:48	303	42	14	62	69	17	39	70	0.0
18 NOV 1984	13:47:2	303	80	9	76	222	27	37	105	0.0
28 NOV 1984	5:49:43	304	34	14	50	134	32	20	67	1.2
28 NOV 1984	8:47:10	305	61	23	147	279	49	30	154	0.0
1 DEC 1984	13:27:19	305	24	32	81	305	24	32	81	2.6
28 NOV 1984	5:49:48	306	130	3	41	189	44	27	125	1.3
28 NOV 1984	8:50:9	306	31	40	130	281	32	39	131	2.5
28 NOV 1984	12:45:3	306	306	1	32	224	15	41	65	2.4
29 NOV 1984	18:34:58	306	29	33	100	197	29	35	106	4.8
28 NOV 1984	10:32:31	308	69	6	43	52	12	38	48	2.9
28 NOV 1984	6:1:15	311	216	2	45	233	61	20	128	1.7
29 NOV 1984	19:52:27	311	35	14	51	114	19	27	54	0.0
28 NOV 1984	2:22:48	312	33	13	45	276	43	14	63	1.5
28 NOV 1984	8:56:4	313	63	23	152	226	67	27	190	1.8
28 NOV 1984	7:47:14	314	39	23	94	314	39	23	94	3.1
28 NOV 1984	7:47:30	314	43	21	95	276	37	36	140	3.0
28 NOV 1984	8:39:30	314	117	3	37	314	117	3	37	1.5
28 NOV 1984	8:7:45	316	30	36	113	316	30	36	113	0.0
19 NOV 1984	13:31:57	318	42	15	66	267	45	14	66	0.0
27 NOV 1984	21:34:10	321	321	1	34	297	76	5	40	0.0
28 NOV 1984	8:45:40	321	26	40	109	233	29	41	125	3.2

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 NOV 1984	8:55:9	321	37	29	113	173	53	23	128	0.0
29 NOV 1984	19:25:54	322	40	20	84	259	33	38	132	4.0
1 DEC 1984	22:56:19	322	63	27	178	258	57	37	221	2.5
1 DEC 1984	14:20:31	323	46	12	58	304	43	19	86	0.0
18 NOV 1984	13:17:28	325	134	3	42	325	134	3	42	0.0
28 NOV 1984	18:48:45	326	59	11	68	316	65	10	68	1.3
28 NOV 1984	8:46:9	327	37	33	128	292	35	38	140	3.2
18 NOV 1984	14:45:46	328	42	12	53	328	42	12	53	0.0
28 NOV 1984	5:45:44	331	40	31	130	260	44	30	138	2.9
18 NOV 1984	13:57:9	332	59	21	130	332	59	21	130	0.0
28 NOV 1984	2:5:18	332	35	27	99	260	33	29	100	0.0
29 NOV 1984	19:45:51	332	21	38	84	332	21	38	84	5.0
29 NOV 1984	20:2:41	332	25	29	76	301	89	10	93	3.1
28 NOV 1984	5:59:31	333	35	32	118	144	34	37	132	0.0
18 NOV 1984	10:40:56	335	59	11	68	310	57	12	72	0.0
27 NOV 1984	22:6:9	335	335	1	35	320	35	11	40	2.1
28 NOV 1984	7:54:32	335	54	18	102	174	52	35	191	1.8
28 NOV 1984	13:13:19	335	28	39	115	335	28	39	115	3.3
29 NOV 1984	12:54:35	335	190	3	60	335	190	3	60	2.5
29 NOV 1984	19:3:40	336	37	41	159	336	37	41	159	4.2
19 NOV 1984	12:21:25	338	86	6	54	180	36	18	68	0.0
28 NOV 1984	8:46:14	338	44	40	185	338	44	40	185	2.8
29 NOV 1984	16:5:37	338	56	29	170	314	57	31	185	3.8
27 NOV 1984	21:49:8	339	62	11	72	339	62	11	72	2.0
29 NOV 1984	10:21:3	339	68	12	86	243	69	14	101	2.5
28 NOV 1984	6:1:5	340	52	20	109	336	46	34	164	2.2
28 NOV 1984	18:6:37	340	58	14	85	340	58	14	85	2.8
28 NOV 1984	8:41:31	342	44	30	138	263	36	37	140	2.2
29 NOV 1984	14:5:10	343	60	10	63	291	28	26	76	1.8
29 NOV 1984	18:23:54	343	37	35	136	255	49	34	175	3.6
28 NOV 1984	6:0:11	344	42	29	128	243	39	41	168	2.7
28 NOV 1984	19:18:55	344	44	14	65	344	44	14	65	0.0
28 NOV 1984	5:58:46	345	81	16	136	275	66	24	166	2.5
29 NOV 1984	20:3:9	345	126	4	53	274	45	17	80	0.0
28 NOV 1984	9:12:28	346	51	36	193	346	51	36	193	2.4
28 NOV 1984	16:1:43	347	42	14	62	205	68	13	93	2.6
29 NOV 1984	20:24:43	347	115	4	48	272	27	20	57	2.9
19 NOV 1984	14:5:56	348	46	9	43	348	46	9	43	0.0
18 NOV 1984	12:15:30	349	245	3	77	310	192	4	81	0.0
28 NOV 1984	17:45:21	349	349	1	37	349	349	1	37	1.3
29 NOV 1984	21:10:26	349	98	7	72	303	34	22	78	2.5
19 NOV 1984	14:6:37	350	40	21	88	350	40	21	88	0.0
18 NOV 1984	10:38:51	351	30	18	57	188	43	17	77	0.0
18 NOV 1984	10:40:35	352	37	31	120	352	37	31	120	0.0
28 NOV 1984	8:1:29	352	32	18	60	352	32	18	60	2.1
28 NOV 1984	16:54:16	354	67	11	77	354	67	11	77	3.0
28 NOV 1984	8:30:59	356	44	23	106	354	37	30	116	3.6
29 NOV 1984	8:45:33	356	30	43	135	254	42	39	172	3.3
28 NOV 1984	7:55:4	361	88	17	157	361	88	17	157	1.5
28 NOV 1984	17:9:7	365	34	15	54	365	34	15	54	2.7

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
19 NOV 1984	12:25:59	367	41	26	112	367	41	26	112	0.0
29 NOV 1984	10:18:45	367	40	35	147	337	46	32	154	2.3
28 NOV 1984	13:50:0	369	23	22	53	369	23	22	53	2.9
28 NOV 1984	8:17:46	372	38	24	96	265	32	38	128	2.9
18 NOV 1984	14:50:47	373	36	42	159	373	36	42	159	0.0
28 NOV 1984	8:7:21	374	35	34	125	180	41	31	133	3.9
28 NOV 1984	16:5:57	376	46	12	58	225	62	12	76	3.2
28 NOV 1984	20:53:50	376	38	34	136	337	43	31	140	2.3
28 NOV 1984	19:19:18	377	50	15	79	335	54	16	102	0.0
29 NOV 1984	10:15:41	377	31	26	85	370	32	30	101	3.0
1 DEC 1984	21:5:5	377	44	24	111	252	59	21	130	.6
28 NOV 1984	8:51:22	379	42	42	185	199	43	42	189	3.8
29 NOV 1984	3:56:15	379	145	4	61	296	30	27	85	3.0
29 NOV 1984	1:54:52	380	188	3	59	229	25	43	113	2.9
27 NOV 1984	18:41:11	383	86	5	45	294	22	27	62	1.8
28 NOV 1984	18:18:9	383	26	34	93	299	28	34	100	3.8
28 NOV 1984	8:49:29	386	56	28	165	386	56	28	165	2.4
28 NOV 1984	8:0:51	387	41	12	52	258	61	16	102	3.4
29 NOV 1984	1:54:13	387	69	15	109	300	71	18	134	2.7
28 NOV 1984	9:10:57	388	41	40	172	388	41	40	172	0.0
28 NOV 1984	14:27:32	388	34	32	114	388	34	32	114	3.7
29 NOV 1984	2:14:20	388	42	30	132	316	58	23	140	1.2
29 NOV 1984	19:11:36	388	34	33	118	388	34	33	118	4.1
19 NOV 1984	12:35:17	390	48	9	45	390	48	9	45	0.0
29 NOV 1984	2:0:26	392	42	27	119	196	56	29	170	3.5
29 NOV 1984	22:15:47	392	40	20	84	366	43	32	144	0.0
29 NOV 1984	18:46:43	393	60	19	120	340	37	40	155	5.5
1 DEC 1984	22:43:55	396	148	6	93	337	139	7	102	3.9
18 NOV 1984	14:28:41	398	64	9	60	317	71	19	142	0.0
18 NOV 1984	14:15:43	399	36	38	144	399	36	38	144	0.0
29 NOV 1984	20:17:26	399	87	11	100	196	31	48	156	0.0
28 NOV 1984	8:0:44	401	176	3	55	210	29	20	61	2.9
28 NOV 1984	8:31:39	402	34	15	54	401	40	13	55	3.0
29 NOV 1984	10:18:34	402	67	29	204	402	67	29	204	3.0
29 NOV 1984	20:23:33	402	215	3	68	366	336	2	71	0.0
28 NOV 1984	18:47:47	403	43	19	86	403	43	19	86	1.8
29 NOV 1984	12:55:41	403	271	2	57	302	39	21	86	1.8
28 NOV 1984	23:20:55	404	36	30	113	404	36	30	113	2.4
19 NOV 1984	13:32:26	406	30	46	145	406	30	46	145	0.0
28 NOV 1984	19:17:23	406	406	1	43	271	42	15	66	0.0
28 NOV 1984	18:9:53	407	45	18	85	407	45	18	85	2.3
29 NOV 1984	20:23:39	407	72	13	98	334	34	36	128	2.0
28 NOV 1984	8:57:53	409	346	2	73	409	346	2	73	1.0
27 NOV 1984	20:19:24	410	56	10	59	386	41	14	60	2.8
28 NOV 1984	8:24:56	410	36	36	136	265	48	29	146	1.3
28 NOV 1984	18:40:7	413	63	10	72	413	63	10	72	0.0
28 NOV 1984	8:24:50	415	80	19	159	231	69	25	181	2.8
28 NOV 1984	8:31:8	415	61	18	115	415	61	18	115	3.4
28 NOV 1984	8:53:27	415	29	25	76	415	29	25	76	3.9
28 NOV 1984	17:45:45	418	418	1	44	418	418	1	44	1.4

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28 NOV 1984	20:59:50	420	59	26	161	420	59	26	161	2.5
18 NOV 1984	14:15:33	424	162	3	51	285	100	13	136	0.0
28 NOV 1984	8:42:39	424	61	20	128	360	54	26	147	2.8
28 NOV 1984	19:25:25	424	37	26	101	340	43	32	144	2.2
28 NOV 1984	5:58:41	427	43	44	198	391	50	42	220	2.6
28 NOV 1984	9:16:2	427	73	24	184	355	99	21	218	2.1
28 NOV 1984	17:2:0	428	80	10	64	428	80	10	64	3.9
28 NOV 1984	20:5:5	429	77	11	89	429	77	11	89	2.7
29 NOV 1984	1:53:58	432	44	31	143	432	44	31	143	0.0
28 NOV 1984	18:30:37	433	433	1	45	327	37	19	74	0.0
29 NOV 1984	2:13:9	434	50	29	152	434	50	29	152	4.3
29 NOV 1984	20:52:44	435	76	10	60	195	42	20	88	4.4
1 DEC 1984	13:55:15	436	45	14	65	350	72	9	68	1.1
29 NOV 1984	20:51:47	439	88	18	165	389	79	21	174	2.3
28 NOV 1984	8:59:28	443	53	22	122	297	45	32	151	2.6
28 NOV 1984	19:26:11	447	77	16	129	447	77	16	129	1.6
18 NOV 1984	14:18:14	453	58	34	207	351	63	33	218	0.0
28 NOV 1984	19:0:2	453	49	17	87	437	37	23	89	2.0
29 NOV 1984	2:13:41	453	453	1	48	241	66	21	145	1.3
28 NOV 1984	8:45:50	457	36	37	140	457	36	37	140	3.1
1 DEC 1984	22:35:26	458	40	45	189	458	40	45	189	3.7
29 NOV 1984	20:5:57	462	99	6	62	153	24	37	93	1.3
29 NOV 1984	10:12:4	469	167	5	88	433	147	6	93	2.7
28 NOV 1984	5:41:3	470	71	21	156	463	62	25	163	1.9
18 NOV 1984	12:59:21	474	22	45	104	474	22	45	104	0.0
28 NOV 1984	14:49:46	476	64	9	50	173	41	26	112	4.0
28 NOV 1984	8:46:45	478	478	1	50	78	19	36	72	1.5
28 NOV 1984	18:9:41	478	53	22	122	246	63	29	192	2.8
29 NOV 1984	21:55:19	478	67	22	155	478	67	22	155	3.8
28 NOV 1984	5:59:23	479	43	29	131	371	43	35	158	2.3
28 NOV 1984	8:54:48	479	179	7	131	445	87	22	201	3.3
28 NOV 1984	3:21:22	486	486	1	51	334	39	17	70	2.6
28 NOV 1984	19:20:56	487	65	15	102	236	68	27	193	2.7
1 DEC 1984	14:15:34	499	38	18	72	499	38	18	72	1.5
28 NOV 1984	8:21:23	501	25	32	84	501	25	32	84	3.3
29 NOV 1984	22:16:32	503	60	25	157	342	74	23	179	0.0
1 DEC 1984	22:49:58	506	114	8	96	506	114	8	96	2.9
28 NOV 1984	18:26:51	507	102	9	96	450	112	10	118	3.0
29 NOV 1984	20:39:54	509	46	36	174	415	44	38	175	0.0
29 NOV 1984	20:18:56	510	68	26	185	510	68	26	185	0.0
28 NOV 1984	18:35:17	511	74	11	85	503	58	15	91	1.3
28 NOV 1984	19:53:2	515	30	34	107	515	30	34	107	3.6
29 NOV 1984	14:14:24	519	153	4	64	406	33	21	73	3.3
19 NOV 1984	14:7:4	520	29	35	106	520	29	35	106	0.0
28 NOV 1984	8:43:3	520	73	23	176	456	76	24	191	2.5
29 NOV 1984	2:9:33	523	57	24	144	355	67	23	152	3.8
28 NOV 1984	6:0:36	524	30	24	76	524	30	24	76	2.3
28 NOV 1984	16:13:20	527	126	7	93	527	126	7	93	0.0
29 NOV 1984	1:55:21	531	43	43	194	531	43	43	194	3.2
28 NOV 1984	7:54:39	537	40	30	126	537	40	30	126	0.0

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18 NOV 1984	13:3:37	538	30	39	123	474	33	38	132	0.0
28 NOV 1984	19:22:30	541	64	22	148	350	38	38	151	3.8
29 NOV 1984	20:50:52	541	219	9	207	443	259	8	217	4.0
28 NOV 1984	19:22:48	544	46	32	154	544	46	32	154	3.5
1 DEC 1984	22:50:5	554	31	43	140	451	28	48	141	2.4
28 NOV 1984	19:7:24	556	65	19	130	487	62	27	176	1.1
28 NOV 1984	9:0:31	556	68	16	114	289	70	16	118	2.3
29 NOV 1984	21:28:17	559	87	8	73	222	24	36	31	2.7
28 NOV 1984	6:46:35	560	105	15	165	398	82	21	181	1.8
28 NOV 1984	19:33:15	561	35	39	143	455	41	35	151	3.6
1 DEC 1984	23:45:35	562	275	5	144	416	73	22	158	3.0
1 DEC 1984	18:36:35	583	167	4	70	464	28	32	94	3.7
1 DEC 1984	14:16:16	589	133	10	140	576	133	11	153	1.3
28 NOV 1984	8:54:57	591	43	28	126	291	63	22	145	2.5
29 NOV 1984	20:40:52	592	592	1	62	575	225	3	71	3.8
29 NOV 1984	19:30:33	599	250	5	131	599	250	5	131	4.2
28 NOV 1984	18:58:33	610	125	7	92	481	108	11	125	2.6
29 NOV 1984	21:26:53	625	89	18	168	267	72	23	174	5.6
28 NOV 1984	18:39:51	634	634	1	67	563	64	11	74	2.6
28 NOV 1984	8:43:23	656	77	20	162	414	101	20	212	0.0
29 NOV 1984	20:35:31	659	59	24	149	639	69	30	217	1.0
29 NOV 1984	10:12:37	666	137	10	144	275	58	43	262	3.5
1 DEC 1984	14:15:42	687	68	15	107	256	27	39	110	1.3
29 NOV 1984	22:16:27	719	56	41	241	699	59	39	241	0.0
28 NOV 1984	5:46:35	729	79	22	182	579	69	35	253	3.3
29 NOV 1984	22:58:23	729	56	46	270	729	56	46	270	3.0
28 NOV 1984	8:44:48	731	93	14	137	519	227	6	143	3.0
29 NOV 1984	12:52:40	733	53	33	183	733	53	33	183	1.3
28 NOV 1984	18:26:46	775	170	12	214	775	170	12	214	3.1
29 NOV 1984	20:35:53	775	206	5	108	506	45	37	175	1.5
28 NOV 1984	19:26:2	785	785	1	82	717	184	19	367	2.5
28 NOV 1984	18:49:50	793	97	14	142	570	158	10	166	2.4
29 NOV 1984	14:35:42	796	293	4	123	554	145	12	183	3.5
28 NOV 1984	18:50:16	811	95	14	140	749	74	18	140	1.2
29 NOV 1984	19:13:3	818	97	33	336	630	83	43	374	4.4
28 NOV 1984	8:7:29	838	260	8	218	673	76	39	311	3.9
28 NOV 1984	19:19:4	1041	399	3	126	628	63	27	178	0.0

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7 APR 1983	14:40:22	274	45	17	87	258	50	20	111	0.0
7 APR 1983	14:44:25	281	65	20	152	266	69	20	159	0.0
19 APR 1983	13:12:30	309	103	5	59	301	175	3	62	7.0
19 APR 1983	13:8:2	312	63	12	83	217	50	24	126	44.5
24 APR 1983	16:16:58	312	63	15	105	256	60	16	108	.8
24 APR 1983	16:16:38	320	132	7	107	302	138	7	110	5.9
24 APR 1983	16:16:52	329	99	7	93	317	122	6	98	1.6
11 APR 1983	9:38:49	333	89	5	52	314	66	9	78	5.0
19 APR 1983	13:6:23	336	19	32	64	178	63	18	123	1.0
19 APR 1983	12:51:52	338	57	20	123	338	57	20	123	.8
15 APR 1983	13:3:2	354	79	8	68	256	95	8	90	1.5
11 APR 1983	8:36:1	358	115	4	67	315	54	11	69	3.9
7 APR 1983	14:44:37	359	43	20	105	359	43	20	105	0.0
11 APR 1983	8:50:10	364	35	38	140	363	37	37	143	7.7
16 APR 1983	12:58:40	367	73	14	146	365	73	22	171	2.1
20 APR 1983	13:10:11	380	57	23	142	380	57	23	142	3.9
19 APR 1983	12:29:54	382	54	35	199	274	56	34	200	5.4
19 APR 1983	12:58:33	390	127	11	153	384	127	11	154	3.8
24 APR 1983	16:17:44	414	81	11	102	414	81	11	102	3.6
11 APR 1983	8:55:57	416	197	5	122	416	197	5	122	1.7
19 APR 1983	13:20:51	416	56	29	175	416	56	29	175	2.1
12 APR 1983	14:15:38	419	41	31	135	240	38	35	142	6.7
24 APR 1983	16:4:14	425	64	21	146	380	67	24	170	4.4
19 APR 1983	12:50:9	434	24	46	118	434	24	46	118	4.7
20 APR 1983	12:43:51	435	37	20	78	301	41	21	93	5.3
20 APR 1983	13:6:47	435	68	28	200	303	63	31	207	.4
19 APR 1983	12:36:34	441	29	35	107	347	37	30	126	3.4
19 APR 1983	13:10:18	443	66	17	131	437	76	28	225	6.9
11 APR 1983	9:38:31	449	104	11	127	331	76	29	236	8.5
20 APR 1983	12:55:17	453	78	8	71	453	78	8	71	1.2
24 APR 1983	15:51:44	453	53	20	180	439	47	25	195	3.3
19 APR 1983	13:17:15	456	102	7	83	328	146	8	130	7.5
11 APR 1983	8:55:8	462	107	13	159	386	78	20	176	8.1
19 APR 1983	12:34:2	472	55	29	176	289	39	47	191	4.6
20 APR 1983	13:6:52	480	56	20	133	240	46	26	134	1.1
19 APR 1983	13:3:44	483	37	43	168	483	37	43	168	5.3
20 APR 1983	13:6:27	485	102	20	214	481	104	22	240	1.4
24 APR 1983	16:16:27	494	57	33	207	486	75	33	266	7.7
11 APR 1983	9:42:52	496	259	3	125	495	259	3	125	8.6
19 APR 1983	12:42:37	496	80	16	168	496	80	16	168	2.2
11 APR 1983	8:55:45	501	324	3	120	398	130	9	132	3.0
24 APR 1983	16:4:39	551	39	39	162	504	40	38	162	1.4
20 APR 1983	12:54:37	554	43	48	216	259	50	44	230	6.2
19 APR 1983	12:38:48	559	120	9	117	281	55	29	172	3.3
11 APR 1983	8:50:37	561	561	1	79	437	99	21	224	4.9
19 APR 1983	12:50:16	573	71	13	98	331	63	19	126	3.4
19 APR 1983	12:39:2	575	56	43	252	557	56	45	264	3.2
19 APR 1983	13:17:26	581	51	21	113	581	51	21	113	5.7
11 APR 1983	8:50:15	591	54	39	221	591	54	39	221	7.2
11 APR 1983	8:50:43	600	290	3	97	373	154	6	116	3.7

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MULTIYEAR

DATE	TIME	Pm1	PA1	A1	F1	Pm2	PA2	A2	F2	VEL
20 APR 1983	12:58:25	607	35	42	155	489	47	34	174	7.1
19 APR 1983	13:1:43	627	88	9	102	477	99	13	172	4.2
11 APR 1983	8:55:18	629	87	9	163	607	402	2	169	6.9
16 APR 1983	13:0:54	652	99	13	190	651	95	14	157	2.1
11 APR 1983	8:55:25	666	105	16	191	611	116	14	192	6.6
20 APR 1983	13:9:55	706	85	26	232	360	83	36	313	7.5
24 APR 1983	16:20:12	715	147	9	149	439	167	8	150	6.6
19 APR 1983	13:12:42	718	124	19	249	713	126	24	319	6.7
19 APR 1983	13:5:56	741	86	14	131	432	92	34	329	4.9
11 APR 1983	8:55:35	799	125	20	259	725	166	15	274	4.4
19 APR 1983	13:10:13	838	100	26	299	672	68	44	314	9.1
19 APR 1983	12:25:12	848	84	24	219	488	69	34	252	4.4
11 APR 1983	8:55:50	1006	180	10	219	740	323	5	234	2.5
11 APR 1983	8:55:30	1011	208	14	318	642	229	10	393	5.6
24 APR 1983	16:11:59	1141	173	27	491	1141	173	27	491	7.8
19 APR 1983	13:3:53	1243	305	7	239	548	100	28	294	5.6
20 APR 1983	13:6:18	1319	496	6	411	956	209	20	443	3.2

BEAUFORT SUMMER 1984
MULTIYEAR

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
1 DEC 1984	13:50:20	117	20	12	25	57	11	25	29	.1
28 NOV 1983	4:29:31	186	78	5	41	155	32	18	60	0.0
1 DEC 1984	13:50:30	199	199	1	21	184	24	9	23	.1
27 NOV 1983	20:1:45	200	27	16	45	87	25	18	47	0.0
27 NOV 1983	20:10:37	202	202	1	21	173	17	14	25	0.0
28 NOV 1983	4:29:0	203	203	1	21	156	33	18	62	0.0
18 NOV 1984	13:49:12	233	62	6	39	179	42	20	88	0.0
18 NOV 1984	13:17:50	234	24	25	63	179	41	16	69	0.0
27 NOV 1983	22:17:1	238	192	2	40	201	40	16	67	0.0
18 NOV 1984	13:49:27	249	20	17	36	177	64	8	54	0.0
18 NOV 1984	13:43:16	265	48	10	50	232	99	5	52	0.0
18 NOV 1984	13:48:4	283	36	10	38	89	25	19	50	0.0
18 NOV 1984	13:1:43	292	36	17	64	144	28	35	103	0.0
18 NOV 1984	13:47:2	303	80	9	76	222	27	37	105	0.0
1 DEC 1984	22:56:19	322	63	27	178	258	57	37	221	2.7
1 DEC 1984	14:20:31	323	46	12	58	304	43	19	86	.1
18 NOV 1984	13:17:28	325	134	3	42	325	134	3	42	0.0
28 NOV 1983	19:18:55	344	44	14	65	344	44	14	65	0.0
28 NOV 1983	19:19:18	377	50	15	79	335	54	18	102	0.0
28 NOV 1983	19:17:23	406	406	1	43	271	42	15	66	.1
28 NOV 1983	18:30:37	433	433	1	45	327	37	19	74	17.8
1 DEC 1984	13:55:15	436	45	14	66	350	72	9	68	40.4
28 NOV 1983	19:26:11	447	77	16	129	447	77	16	129	0.0
28 NOV 1983	19:0:2	453	49	17	87	437	37	23	89	2.1
28 NOV 1983	5:41:3	470	71	21	156	463	62	25	163	0.0
29 NOV 1984	22:16:32	503	60	25	157	342	74	23	179	3.3
28 NOV 1983	19:7:24	556	65	19	130	487	62	27	176	1.1
1 DEC 1984	14:16:16	589	133	10	140	576	133	11	153	3.5
29 NOV 1984	20:35:31	659	59	24	149	639	69	30	217	1.0
29 NOV 1984	22:16:27	719	56	41	241	699	59	39	241	4.9
29 NOV 1984	20:35:53	775	206	5	108	506	45	37	175	2.4
28 NOV 1983	19:19:4	1041	399	3	126	628	63	27	178	0.0

APPENDIX B

USE OF EXTREME VALUE STATISTICS IN ENGINEERING ANALYSIS

Random phenomenae, such as ice loads, wind speed and wave heights can be quantified using statistical techniques. Probability density functions describe the chances of any value occuring in a given sample rather than predicting a certain value. Most statistical methods deal with the analysis of the behaviour of the random variable around the mean (i.e. Traffic Volumes, Mortality Rates, I.Q.). However, certain classes of problems demand that the rare events be investigated. This is particularly true in engineering where the rare event is normally the design event (i.e. fastest wind, highest wave, largest load). The statistical theory of extreme values has been developed to describe the probabilities of these rare events.

Gumbel [1] stated: "The aim of a statistical theory of extreme values is to explain observed extremes... and to forecast (future) extremes". Extreme value functions naturally depend on the initial or underlying distributions. Figure 1 illustrates this with an initial distribution $F_X(x)$ the random variable X, and the distribution of the extremes $G_{Y_N}(y_n)$ where;

$F_X(x)$ = probability that any X will be less than x

$G_{Y_N}(y_n)$ = probability that any Y_N will be less than y_n

where X = random variable,

x = a specific value which X might take

Y_N = Max of N samples of X (also a random variable)

y_n = a specific value which Y_n might take

For Y_N to be less than y_n, all N X must be less than y_n. It follows that;

$$G_Y(y_n) = [F_X(x)]^N_{x = y_n} \qquad (1)$$

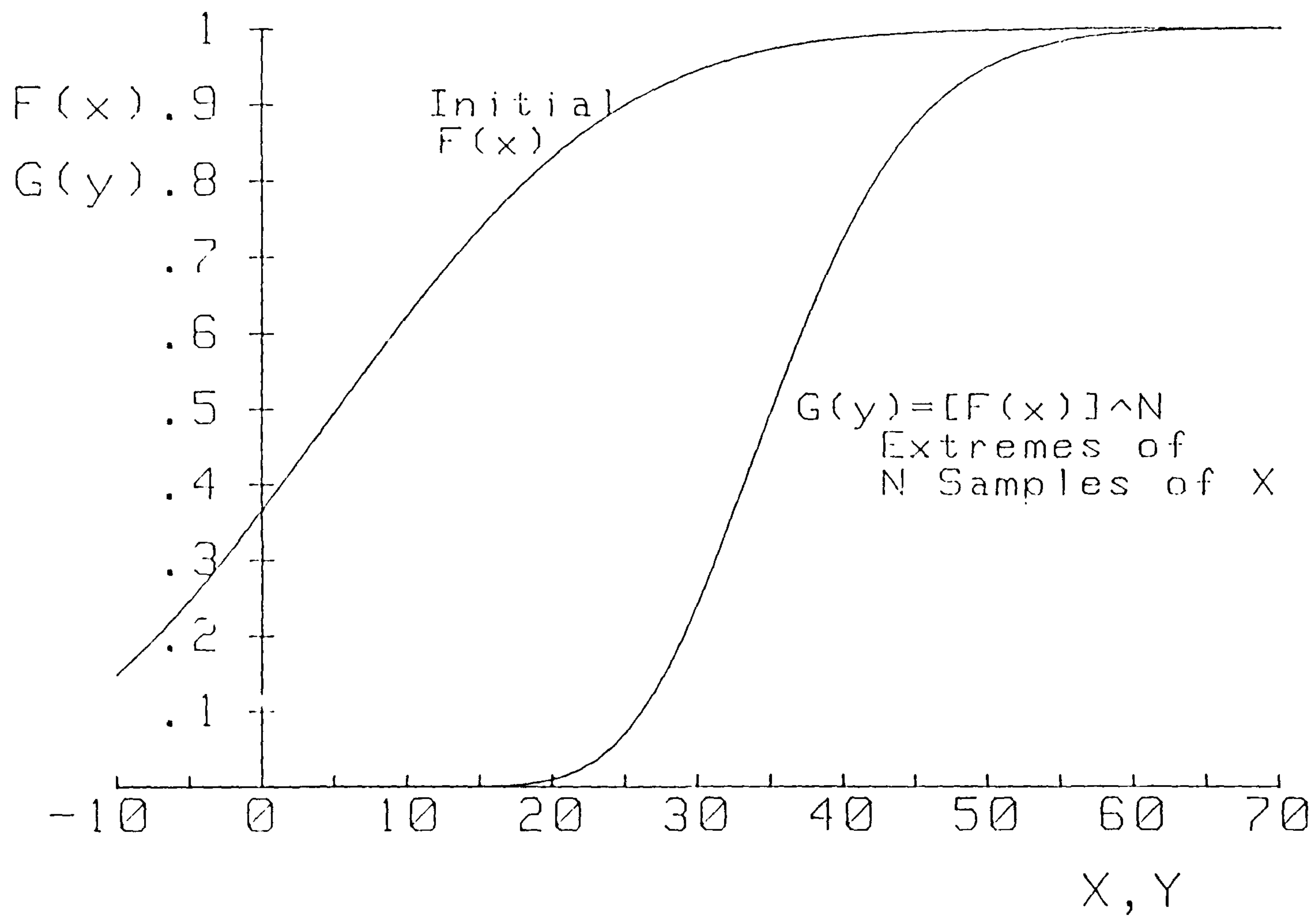

Figure EV.1 EXACT DERIVATION of EXTREME VALUE DISTRIBUTION (G(y)) FROM INITIAL DISTRIBUTION (F(x))

Thus, if the initial distribution of a Function is known exactly, then the extreme value function can be derived exactly. In engineering practice this is not usually possible. Small errors in estimates of the initial distribution are compounded (to the N^{th} power) in the extremes. It is precisely due to this problem that statistical theory of extreme values was developed. The early works on extreme value statistics are due to Von Mises (1922), Frechet (1927) and Fischer and Tippett (1928). Gumbels' landmark paper and book [1,2] give both the mathematical derivation and engineering uses of extreme distributions. There are three main types of extreme value functions, (see Table 1) originally classified by Fischer and Tippett, and which have also come to be known by the mathematicians who studied them; Type I (Gumbel), Type II (Frechet) and Type III (Weibull). All three distributions have a largest value and smallest value form. Only the largest value forms will be discussed here.

Asymptotic Distributions

The reasons that three specific extreme value distributions have been defined is that they are all asymptotic distributions. For most situations of practical importance, for a wide range of initial distributions, the extremes as defined in Equation (1) will asymptotically approach one of the three distributions, as the value of N grows large.

Type I (Gumbel)

The Type I distribution arises when dealing with unlimited random variables whose initial distributions tail off "in an exponential manner"; as for example,

$$F(x) = 1 - e^{-\lambda x} \qquad (2)$$

which is the negative exponential distribution. The normal and gamma distribution are of this general type. The Type I, defining the largest of many independent random variables with a common exponential type of upper tail, is written as:

$$F_Y(y) = e^{-e^{-\alpha(y-u)}} \qquad -\infty < y < \infty \qquad (3)$$

where α = measure of dispersion

u = mode of y

Type II (Frechet)

The Type II also represents the largest of many random variables, but which are limited on the left to zero (i.e. positive only) and have a tail which falls off as:

$$F x) = 1 - \beta \left(\frac{1}{x}\right)^{k} \qquad x > 0 \qquad (4)$$

The Cauchy and log normal follow this form. The Type I and Type II have the same relationship as the normal and log normal distributions. If a variable is log normally distributed then its logarithm is normally distributed, and if a variable is Type II then its logarithm is Type I. This can be seen in the probability paper used to plot Type I and Type II. Both Type I and II use the same scale for probability, but while Type I uses a linear vertical scale, Type II uses a logarithmic scale (see Figures 2 and 3). Note also that if x in Equation 4 is replaced with lnx, then equation 4 can be transformed into equation 2. All this leads to the Type II distribution with the form;

$$F(y) = e^{-\left(\frac{\nu}{y}\right)^{k}} \qquad y > 0 \qquad (5)$$

where ν = a parameter between the mode and median

k = a measure of dispersion.

Type III (Weibull)

The Type III distribution describes the largest of many random variables which are limited to some maximum value w, and fall off in a manner such that near w;

$$F(x) = 1 - c(w - x)^{k} \qquad x < w \quad k > 0 \qquad (6)$$

The distribution of the largest values is:

$$F(y) = e^{-\left(\frac{w-y}{w-u}\right)^{k}} \qquad y < w \qquad (7)$$

TABLE EV.1

PROPERTIES OF TYPES I, II AND III EXTREME VALUE DISTRIBUTIONS

PROPERTIES	FISCHER-TIPPETT TYPE I (Gumbel) Largest Values	FISCHER-TIPPETT TYPE II (Frechet) Largest Values	FISCHER-TIPPETT TYPE III (Weibull) Largest Values
Cumulative Distribution $F_{(y)}$	$F_{(y)} = e^{-e^{-\alpha(y-u)}}$	$F_{(y)} = e^{-(\frac{v}{y})^k}$	$F_{(y)} = e^{-(\frac{w-y}{w-u})^k}$
Probability Density f	$f_{(y)}=\alpha e^{-[\alpha(y-u)+e^{-\alpha(y-u)}]}$	$f_{(y)} = \frac{k}{v}\ (\frac{v}{y})^{k+1}\ e^{-(\frac{v}{y})^k}$	$f_{(y)} = \frac{k}{w-u}(\frac{w-y}{w-u})^{k-1} \cdot F_{(Y)}$
mode	$\tilde{y} = u$	$\tilde{y} = v(\frac{k}{(k+1)})^{1/k}$	$\tilde{y} = u$
mean	$\bar{y} = u + \frac{.57722}{\alpha} = u + .45\sigma$	$\bar{y} = v\Gamma(1-1/k)$	$\bar{y} = w - (w-u)\ \Gamma(1+1/k)$
median	$\breve{y} = u + \frac{.36651}{\alpha}$	$\breve{y} = v(1.44629)^{1/k}$	
Standard Deviation	$\sigma = \frac{1.2825}{\alpha}$	$\sigma = v\sqrt{\Gamma(1-2/k)}$	
Notes:	Most Common E.V. Distribution. Represents the extremes of many standard initial distributions incl. the "normal" distribution.	If $F_{(Y)}$ is Type II then F (log(Y)) is Type II	If $w \rightarrow \infty$ Type III $\rightarrow$ Type I
Limits on Y	Unlimited (+ and -)	Positive Only	Limited to w in the tail of interest.

where w = maximum possible value of y

u = mode of y

k = measure of dispersion

Weibull [1934] actually used the distribution to study smallest rather than largest values. He studied material strength in tension and fatigue. While his justification for the distribution was purely empirical, Freudenthal [1951, 1956] has given physical reasons for its practicability.

Example

The maximum annual mean hourly wind speed for London airport for the years 1939-1961 inclusive are as follows;

36, 37, 45, 50, 39, 33, 37, 35, 41, 52, 41, 58,
39, 46, 39, 42, 45, 36, 55, 32, 43, 34, 39

To plot the extreme values the data must be ranked as follows:

RANK m	VELOCITY (MPH)	$P(v) = 1 - \frac{m}{n+1}$	$Y = -\ln(-\ln(P))$
1	58	.958	3.15
2	55	.917	2.44
3	52	.875	2.01
4	50	.833	1.70
5	46	.792	1.46
6	45	.750	1.25
7	45	.708	1.06
8	43	.667	.90
9	42	.625	.75
10	41	.583	.62
11	41	.542	.49
12	39	.500	.37
13	39	.458	.25
14	39	.417	.13
15	37	.375	.02
16	37	.333	-.09
17	37	.292	-.21
18	36	.250	-.33
19	36	.208	-.45
20	35	.167	-.58
21	34	.125	-.73
22	33	.083	-.91
23	32	.042	-1.16

$\bar{v} = 41.39 \qquad \sigma = 6.87$

The data can be plotted against any of the three distributions. This is best done by first linearizing the equations as follows:

Type I

$$F(x) = e^{-e^{-\alpha(x-u)}} \quad (3)$$

can be converted to:

$$-\ln(-\ln(F(x))) = \alpha x - \alpha u$$

which is linear in $-\ln(-\ln(F(x)))$ and x. The plotting paper used in Figure 2 is specially constructed so that data fitting Equation 3 will be a straight line.

Type II

$$F(x) = e^{-\left(\frac{v}{x}\right)^k} \quad (5)$$

can be converted to:

$$-\ln(-\ln(F(x))) = k\ln x - k\ln v$$

which is linear in $-\ln(-\ln(Fx)))$ and $\ln x$. The same kind of plotting paper can be used to plot Type II if log x is used. Figure 3 uses a logarithmic scale instead.

Type III

$$F(x) = e^{-\left(\frac{w-x}{w-u}\right)^k} \quad (7)$$

can be converted to:

$$-\ln(-\ln(F(x))) = k\ln(w-u) - k\ln(w-x)$$

which is again linear. Figure 4 plots w-x on a logarithmic scale.

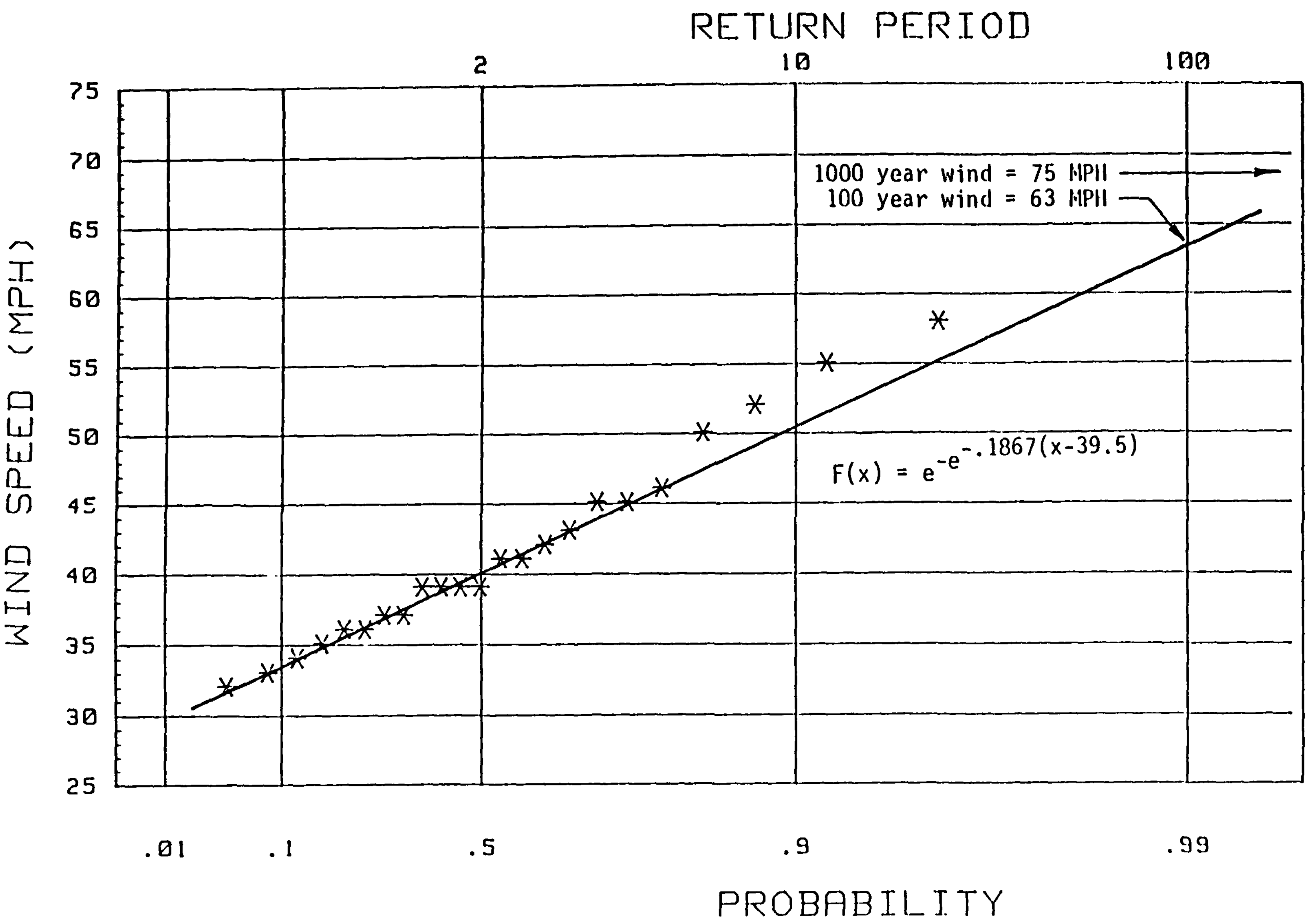

FIGURE EV.2 TYPE I EXTREME VALUE PLOT OF WIND SPEEDS

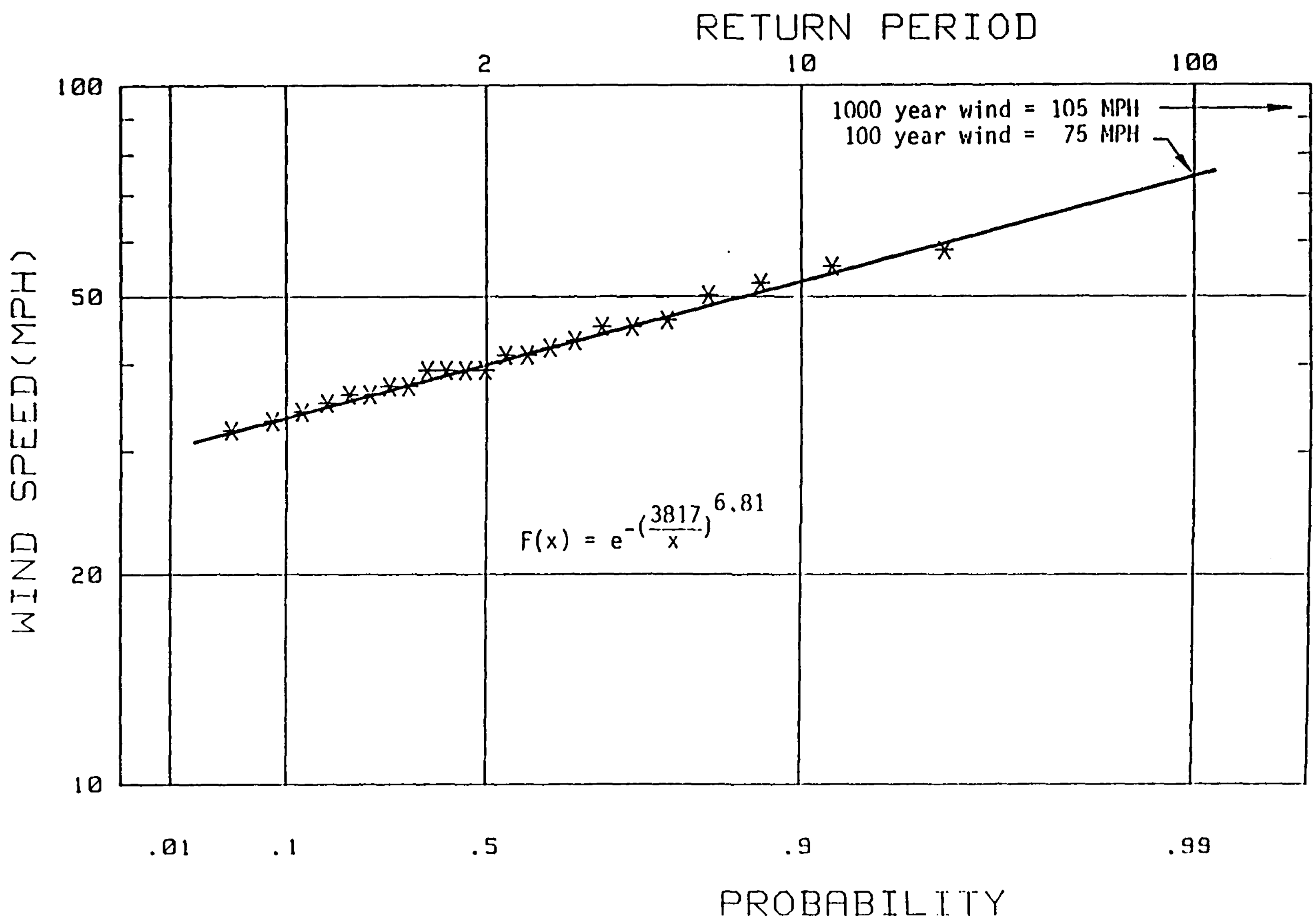

FIGURE EV.3 TYPE II EXTREME VALUE PLOT OF WIND SPEEDS

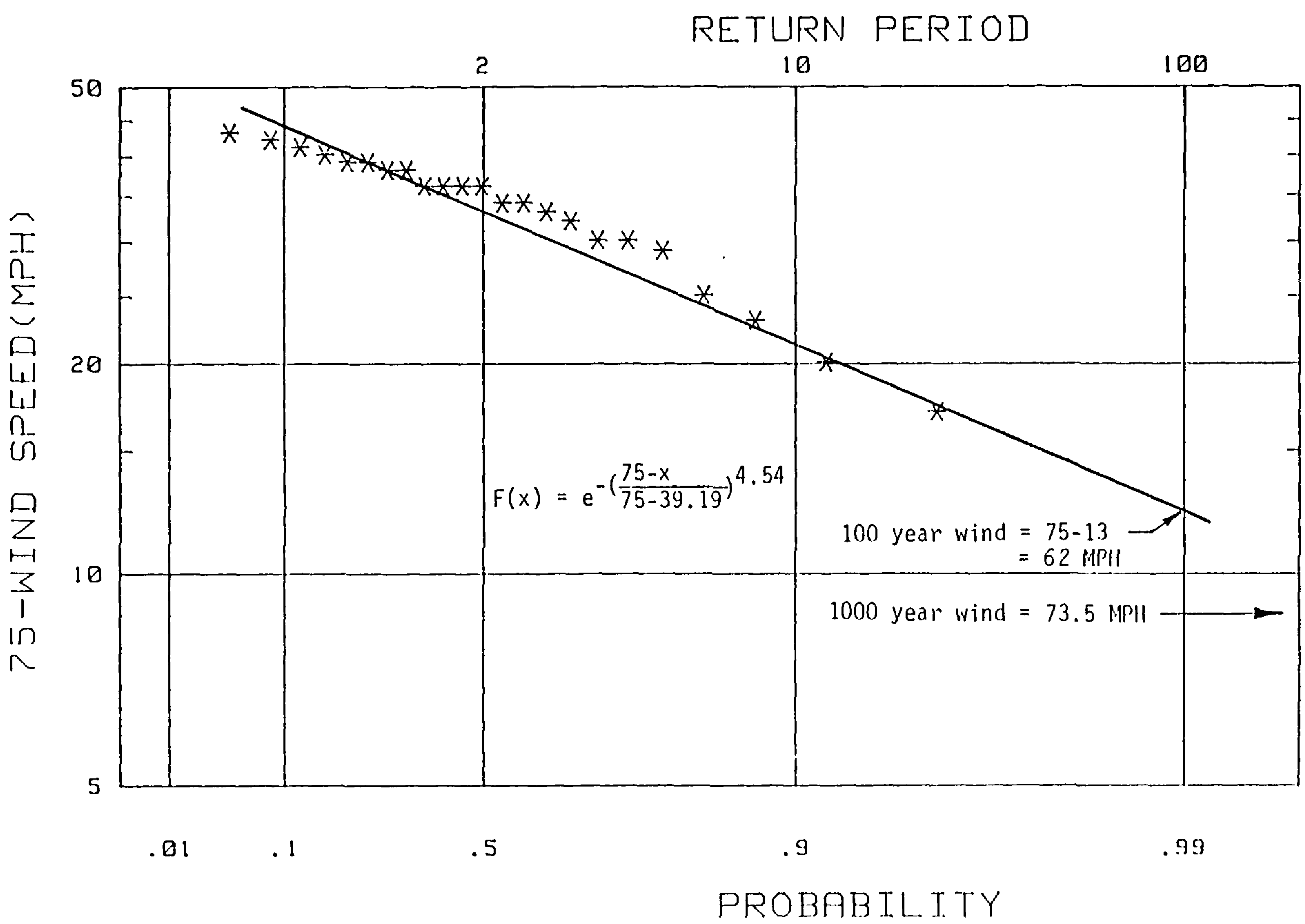

FIGURE EV.4 TYPE III EXTREME VALUE PLOT OF EXTREME WINDS

COMPARISON OF DIFFERENT DISTRIBUTIONS

This example illustrates a very important point concerning extreme value statistics. All three distributions fit the data reasonably well over the range of the data. If one were interested in predictions within the range of probabilities given, the choice would be inconsequential. The problem arises when extrapolating to longer time spans than the available data. The 100 year and 1000 year expected extreme winds are:

	100 yr.	1000 yr.
Type I	63	75
Type II	75	105
Type III	62	73.5

When extrapolating 2, 3 or even 4 orders of magnitude (i.e. from 2 ship weeks of ice loads data to 50,000 ship-weeks of operations) the problems of divergence of the distributions is even greater.

The choice of the distribution must rely on the applicability of assumptions governing the distributions to the particular process governing the data. The key distinguishing aspects of the distributions are:

Type I - unlimited additive (averaging)process
Type II - unlimited multiplicative (sequential) process
Type III - limited variable

The extreme value method is a valuable predictive tool, but care must be taken to get sufficient data and to use the method wisely.

THE THREE DISTRIBUTIONS COMBINED

It has been shown (Gnedenko 1943) that the three Fisher Tippett distributions are the only stable asymptotic forms for extreme values (except for improper distribution). Further, Jenkinson (1955) showed that all three forms could be expressed as special cases of a more general distribution. For the purposes of clarity this most general distribution will be called the Jenkinson distribution. It is written as follows:

$$F(x) = e^{-\left[1 - \frac{C}{A2}(x - A1)\right]^{1/C}} \qquad (8)$$

This reduces to a type I, II or III depending on the value of C, as follows;

Type I: $C = 0$

$$F(x) = e^{-e^{-1/A2\,(x - A1)}}$$

where $1/A2 = \alpha$, $A1 = U$

Type II: $C < 0$

$$F(x) = e^{-\left[\frac{A1/C}{x-(A1 - A2/C)}\right]^{-1/C}}$$

where $X_{min} = A1 - A2/C$ (lower limit, usually 0)

$-1/C = k$

$A2/C = V$

Type III: $C > 0$

$$F(x) = e^{-\left[C/A2\ [(A2/C + A1) - x]\right]^{1/C}}$$

where $X_{max} = W = A1 + A2/C$ (upper limit)

$$1/C = K \qquad A1 = U$$

These interrelationships allow fitting data to equation 8 and then determining both the type and parameters of the extreme value equation.

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[1] Gumbel, E.J. "Statistical Theory of Extreme Values and Some Practical Applications", U.S. National Bureau of Standards, Applied Mathematics, Series 33, Washington D.C., 1954.

[2] Gumbel, E.J., Statistics of Extremes, Columbia Univ. Press, New York, 1958.

[3] Benjamin, J.R. and Cornell, C.A., Probability, Statistics and Decision for Civil Engineers, McGraw-Hill, New York, 1970.

[4] Ghiocel, D., Lungu, D., Wind, Snow and Temperatures Effects on Structures Based on Probability, Abacus Press, Tunbridge Wells, Kent, England 1975.

[5] Ochi, M.K. "Principles of Extreme Value Statistics and Their Application", SNAME publication, presented at Extreme Loads Response Symposium, Arlington, V.A. 1981.

APPENDIX C

TABLE 1

SUMMARY OF DEPLOYMENTS, DATA SETS AND ICE CONDITIONS

TITLE & DATE	LOCATION	ICE TYPE	NO OF EVENTS
Beaufort Summer 82 Sep 28 - Oct 16	100-150 nm north of Prudhoe Bay in the Alaskan Beaufort Sea	MY	167
S Bering Winter 83 Mar 24 - Mar 26	Transit from St.Paul Is. to the west end of St.Lawrence Is. in the Bering Sea	FY	173
N Bering Winter 83 Mar 27 - Mar 28	Transit from St. Lawrence Is. to the Bering Strait in the Bering Sea	FY	241
S Chukchi Winter 83 Mar 29 -Apr 2 Apr 28 - May 2	Transit from the Bering Strait to Point Hope in the Chukchi Sea and return	FY,MY	299
N Chukchi Winter 83 Apr 3 - Apr 27	Round trip transit Point Hope to Wainwright in the Chukchi Sea, operation off Wainwright	FY,MY	513
Antarctic Summer 84 Jan 9 - Jan 13	McMurdo Sound, break-in to McMurdo Base	FY	309
Beaufort Summer 84 Nov 18 - Dec 1	Operation between Barter Is. and Barrow in the Beaufort Sea, transit through the Chukchi Sea to the Bering Strait	FY,MY	337

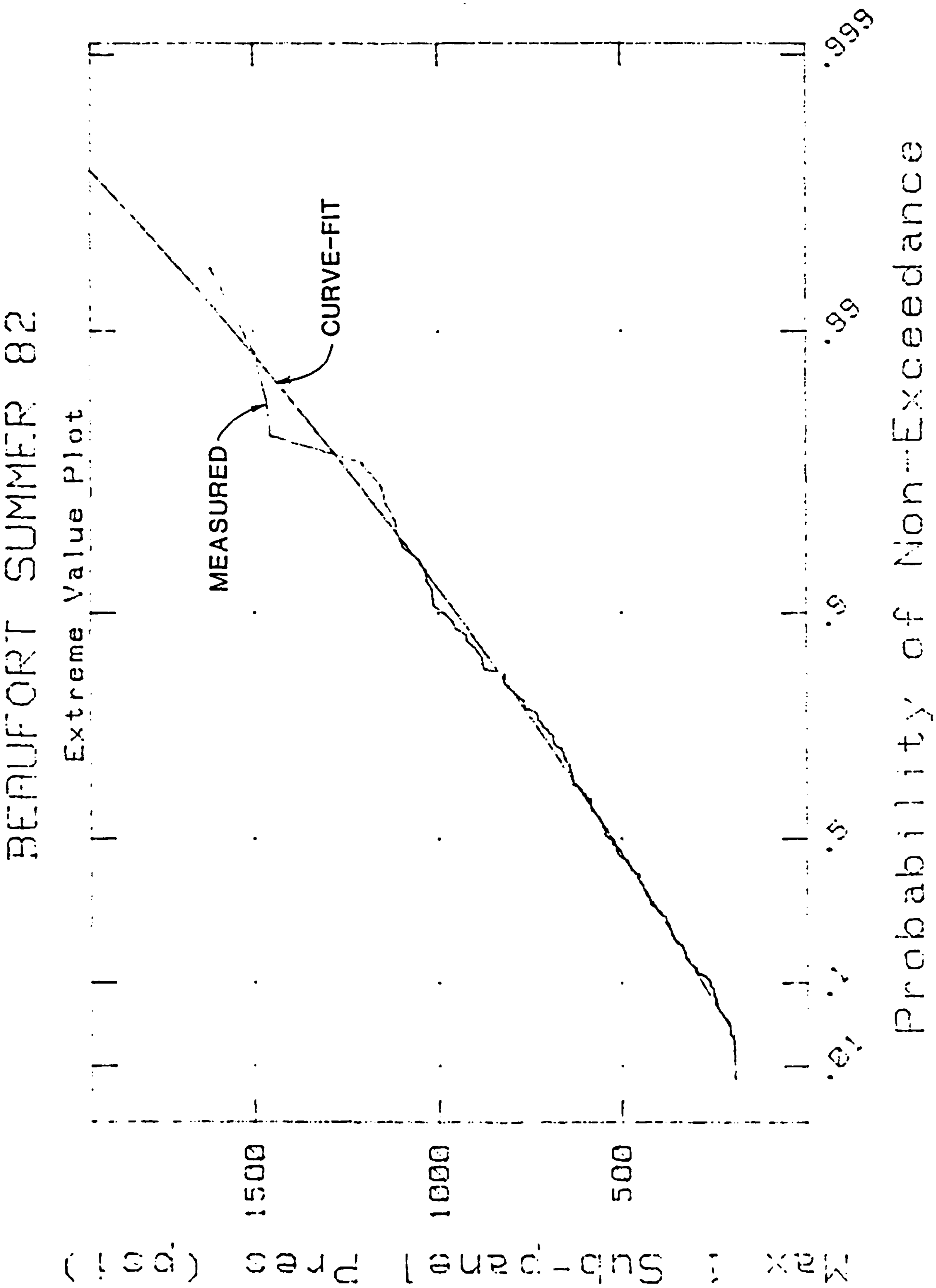
SUBSETS OF KNOWN MULTIYEAR EVENTS

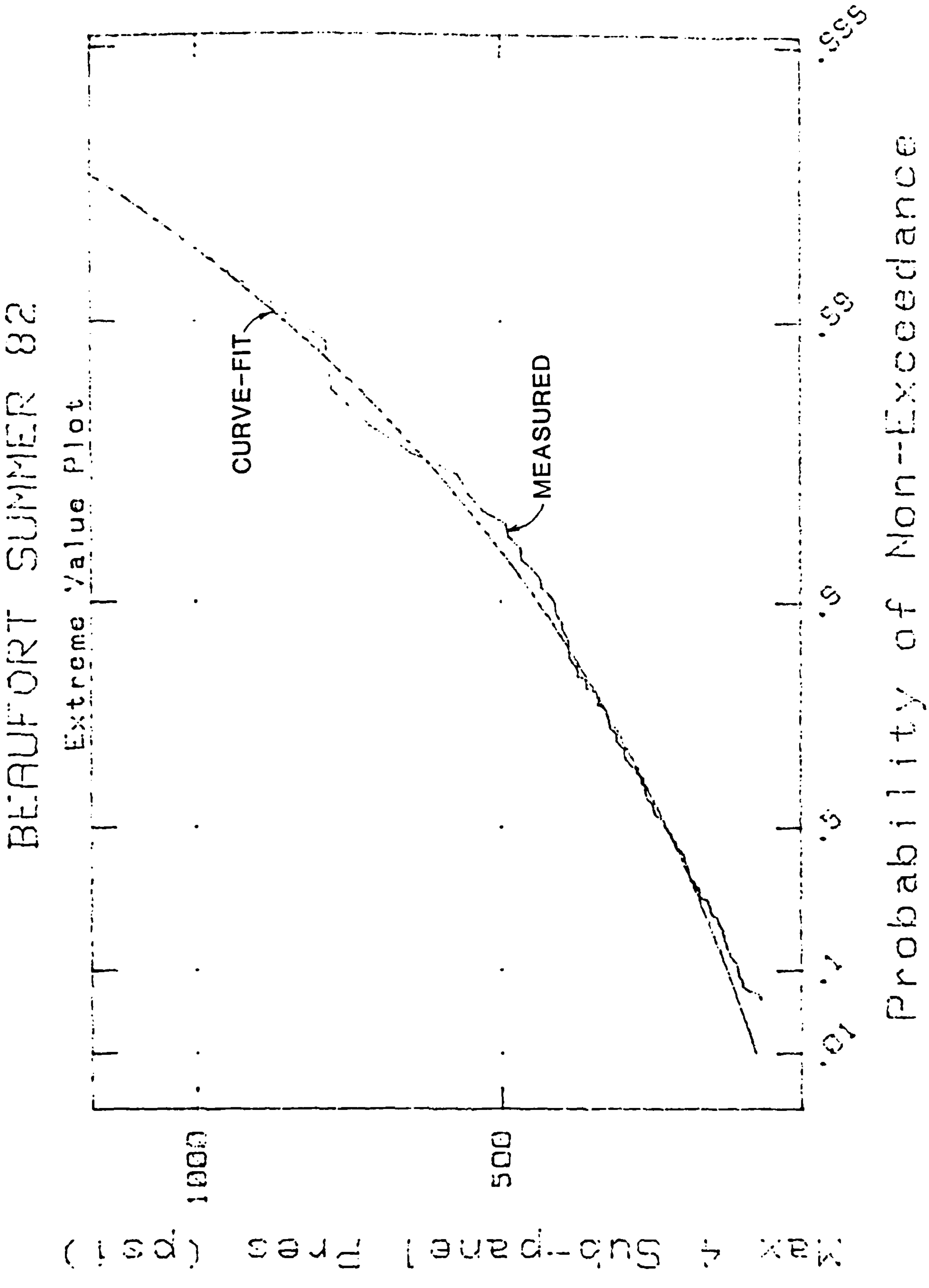
TITLE & DATE	LOCATION	ICE TYPE	NO OF EVENTS
N Chukchi Winter 83 MY Apr 3 - Apr 27	North Chukchi Sea off Wainwright	MY	67
Beaufort Summer 84 MY Nov 12 - Dec 1	Beaufort and Chukchi Seas	MY	32

TABLE 2

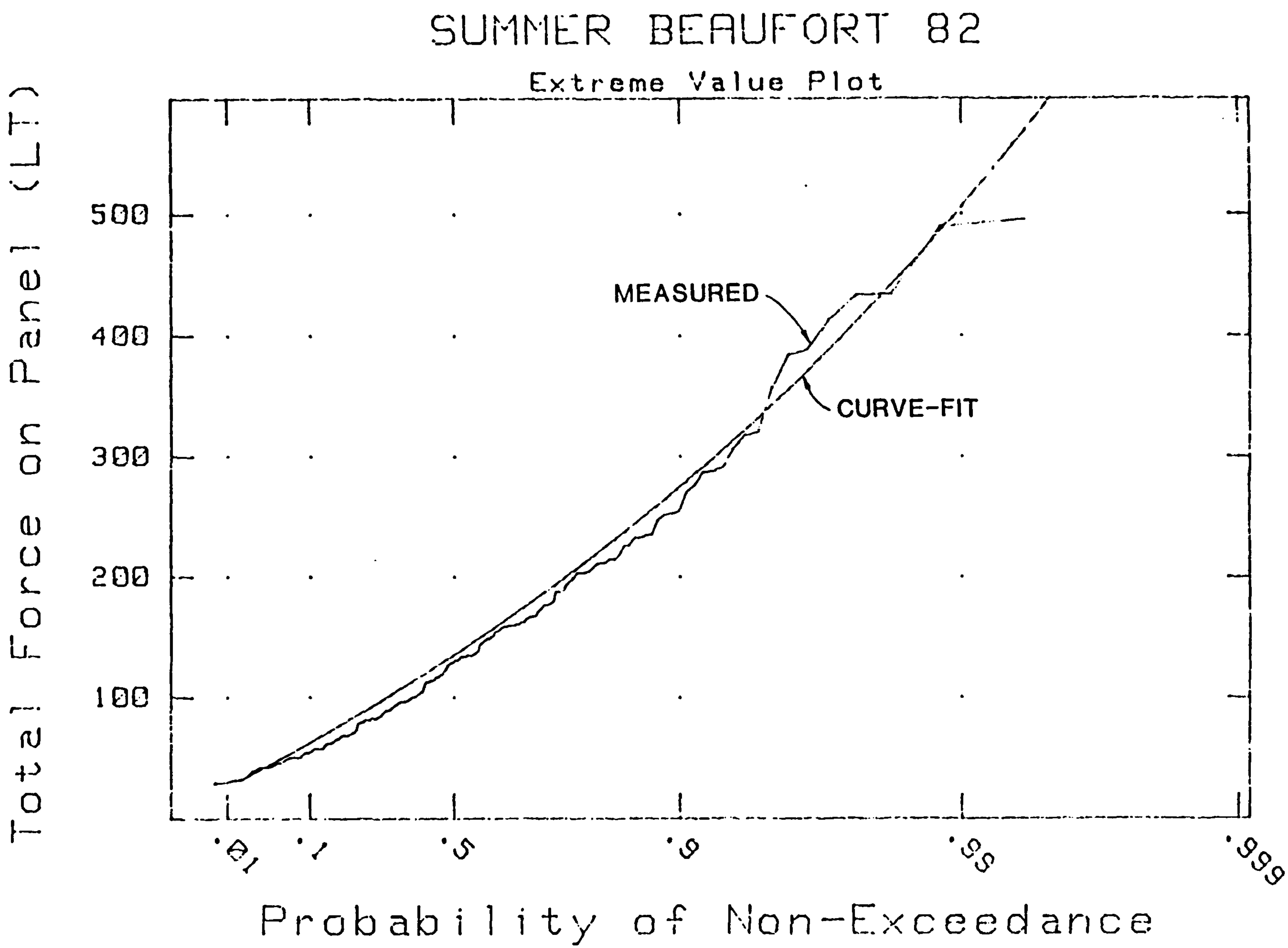
SUMMARY OF COMBINED DATA SETS

TITLE	COMBINED FROM	ICE TYPE	NO OF EVENTS
Known Multiyear	Beaufort Summer 82 N Chukchi Winter 83 MY Beaufort Summer 84 MY	MY	266
Heavy Mixed FY & MY	Beaufort Summer 82 S Chukchi Sea 83 N Chukchi Sea 83 Beaufort Summer 84	FY,MY	1017
Known First Year	S Bering Winter 83 N Bering Winter 83 Antarctic Summer 84	FY	723
Summer Beaufort Sea	Beaufort Summer 82 Beaufort Summer 84	mostly MY	504
Winter Chukchi Sea	S Chukchi Winter 83 N Chukchi Winter 83	FY,MY	398
Winter Bering Sea	S Bering Winter 83 N Bering Winter 83	FY	812

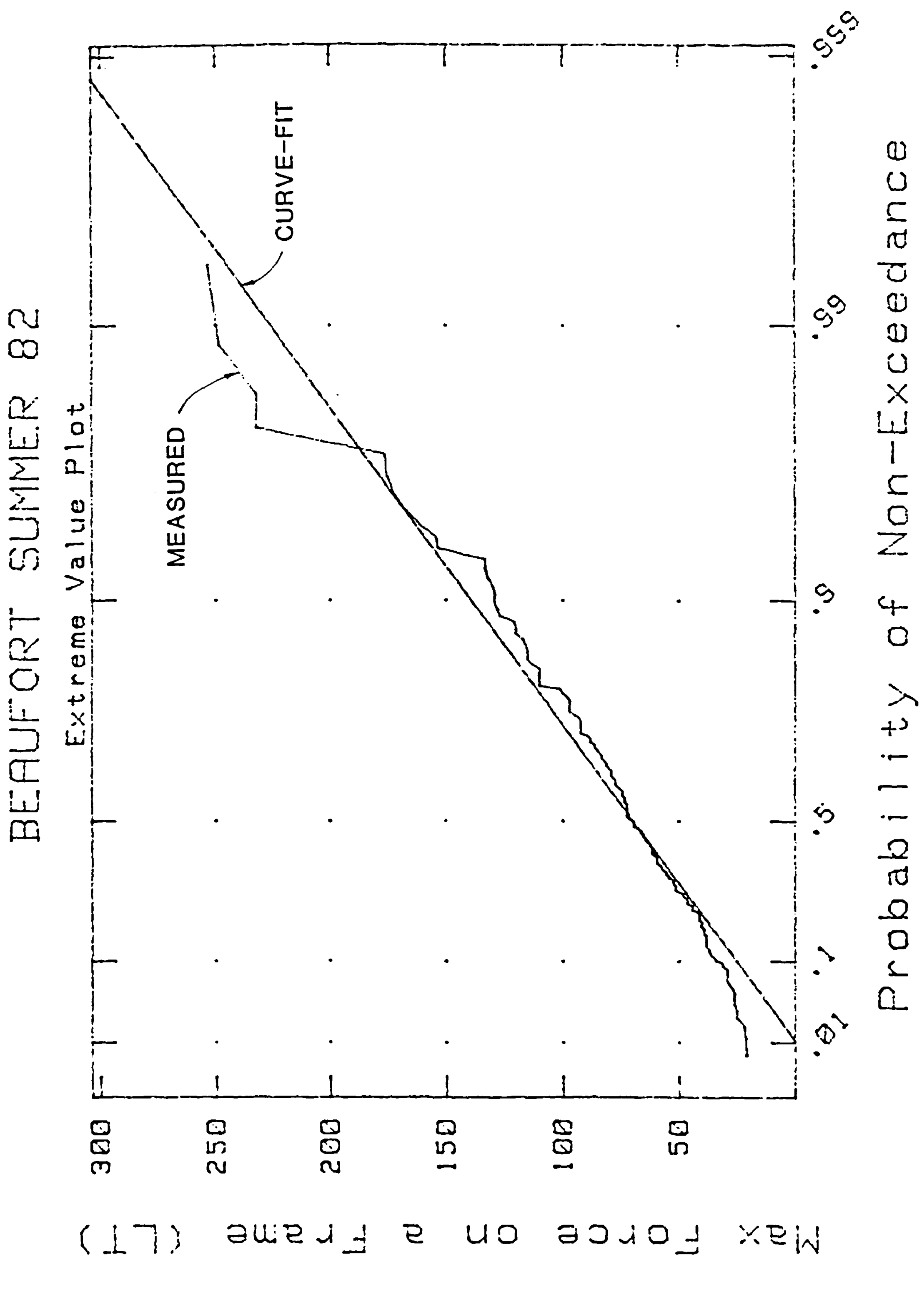

BEAUFORT SUMMER 82
Extreme Value Plot
CURVE-FIT
MEASURED
1500
1000
500
.01
.2
.5
.9
.99
.999
Probability of Non-Exceedance
Max I Sub-panel Pres (psi)

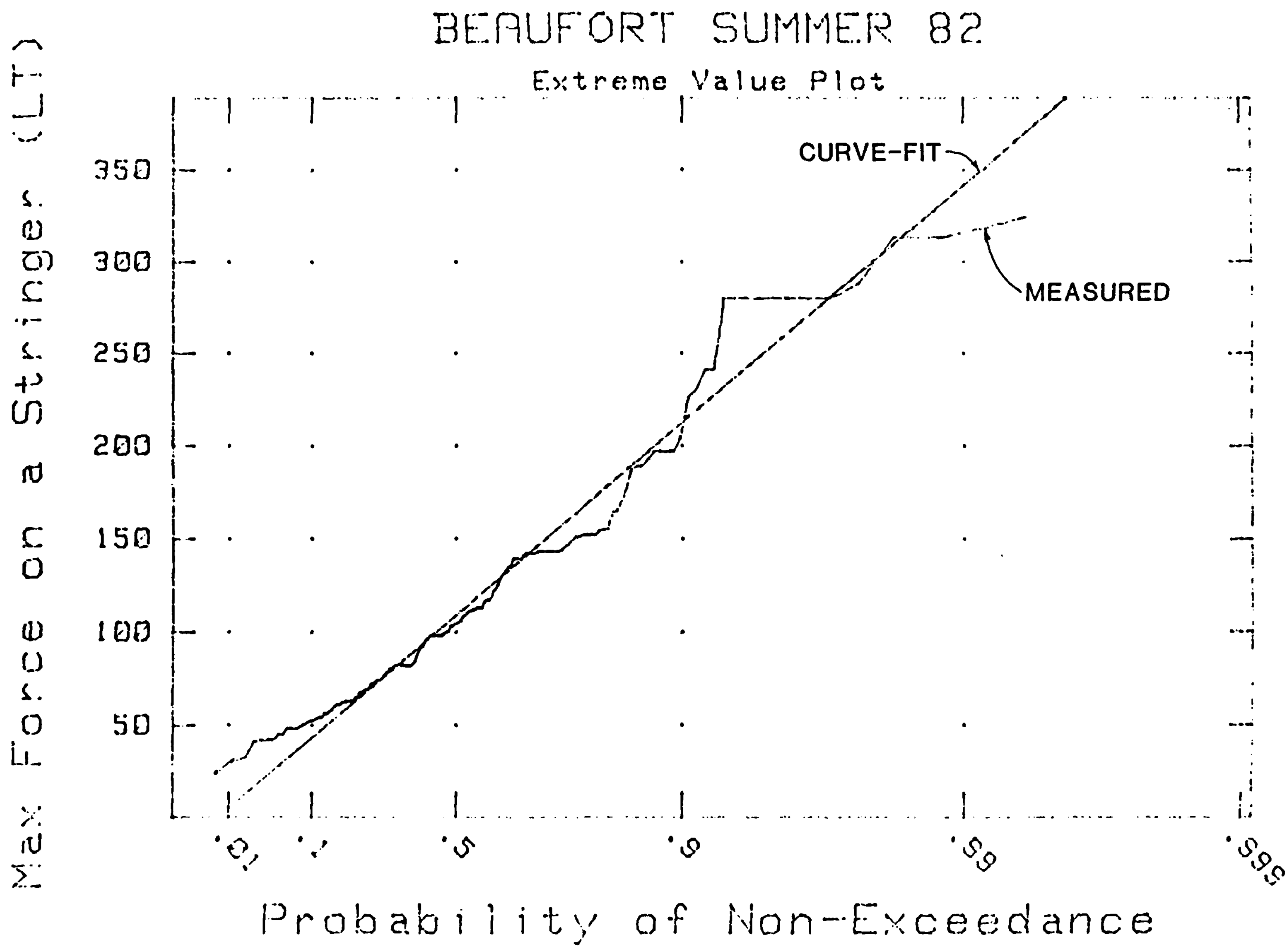


BEAUFORT SUMMER 82
Extreme Value Plot
CURVE-FIT
MEASURED
1000
500
Max 4 Sub-panel Pres (psi)
.01
.1
.3
.5
.9
.999
Probability of Non-Exceedance

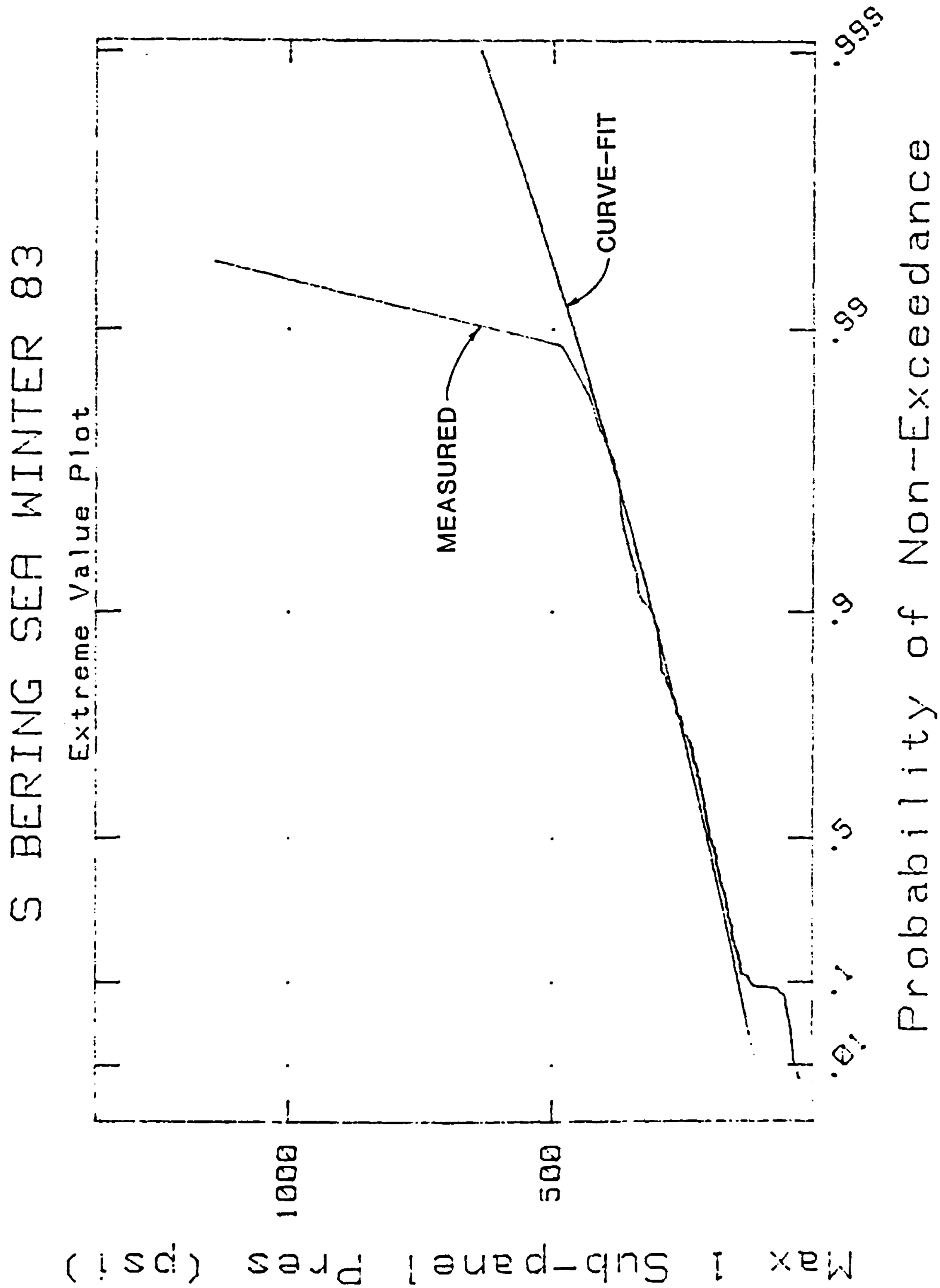


SUMMER BEAUFORT 82
Extreme Value Plot
Total Force on Panel (LT)
500
400
300
200
100
MEASURED
CURVE-FIT
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

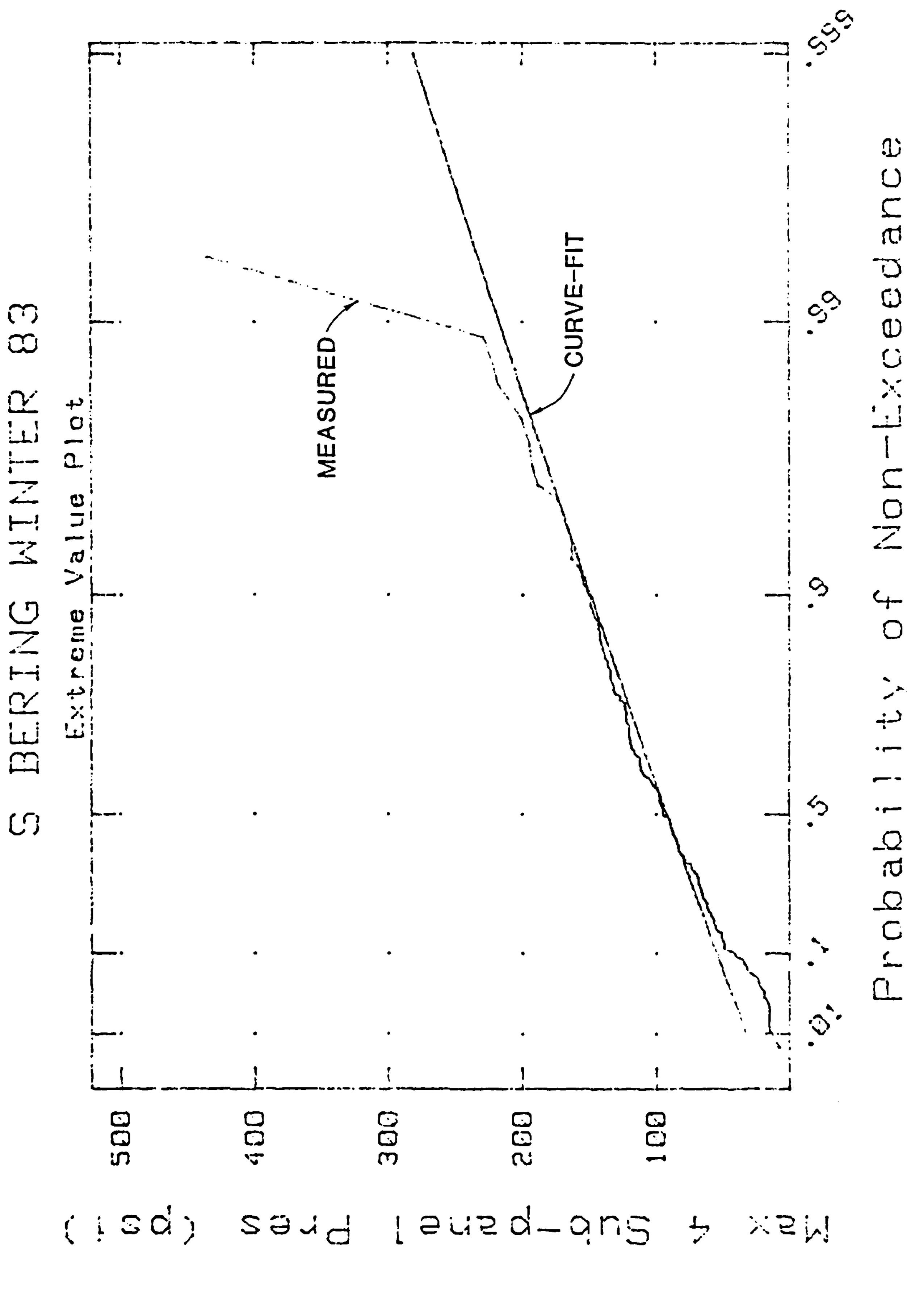

BEAUFORT SUMMER 82
Extreme Value Plot
CURVE-FIT
MEASURED
Probability of Non-Exceedance
Max Force on a Frame (LT)
300
250
200
150
100
50
.01
.1
.5
.9
.99
.999

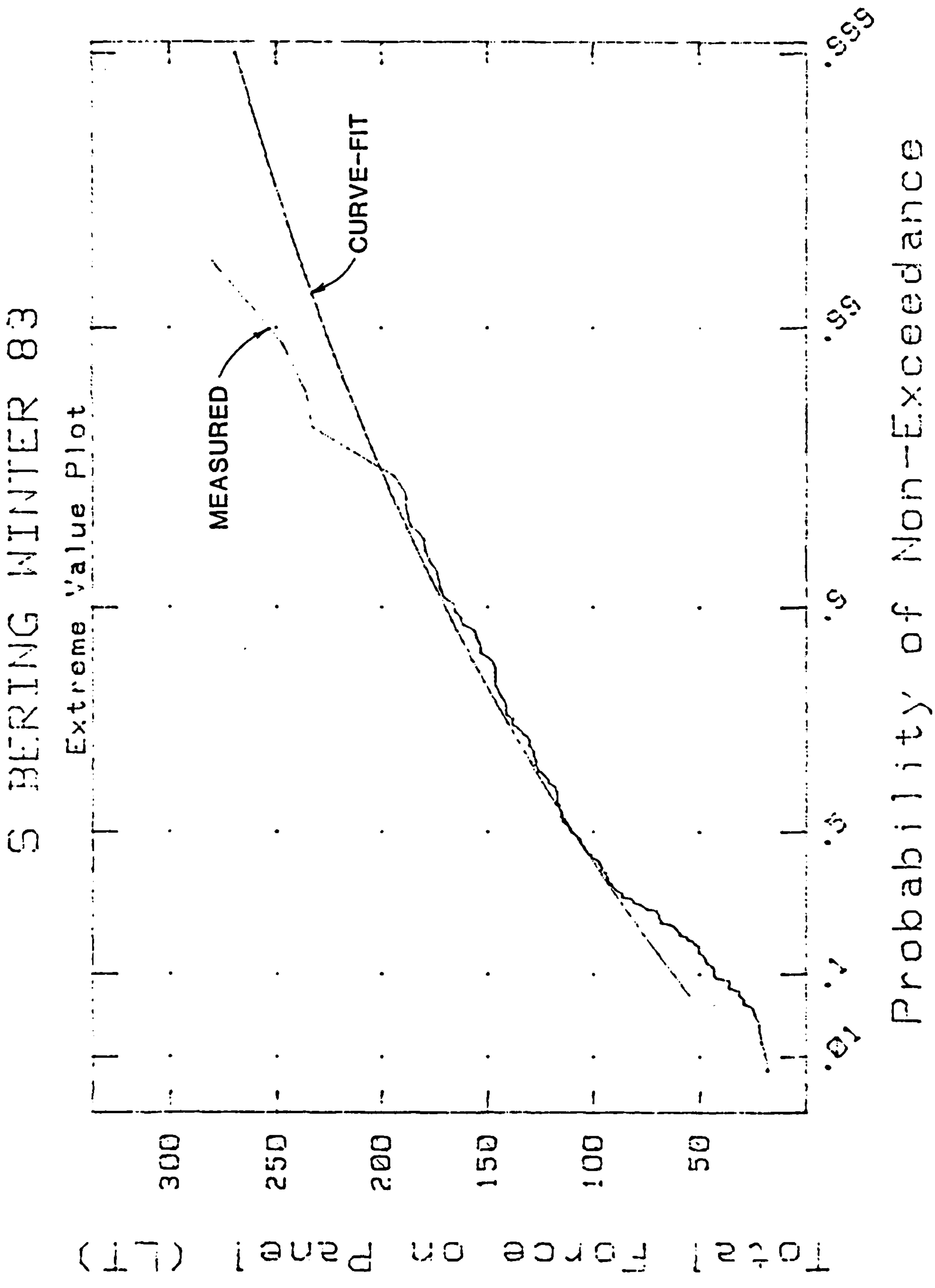


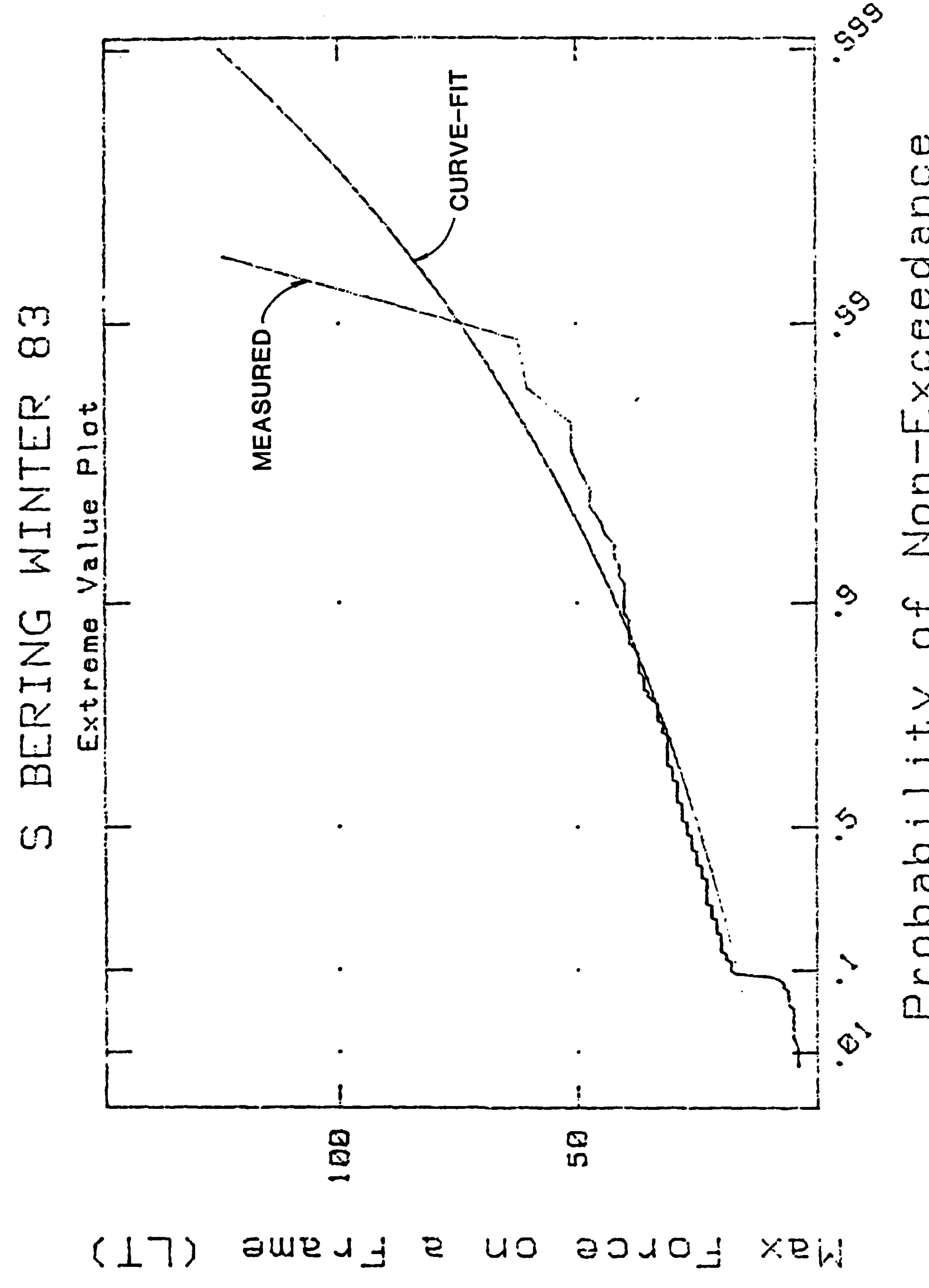
BEAUFORT SUMMER 82
Extreme Value Plot
CURVE-FIT
MEASURED
350
300
250
200
150
100
50
.01
.1
.5
.9
.99
.995
Max Force on a Stringer (LT)
Probability of Non-Exceedance



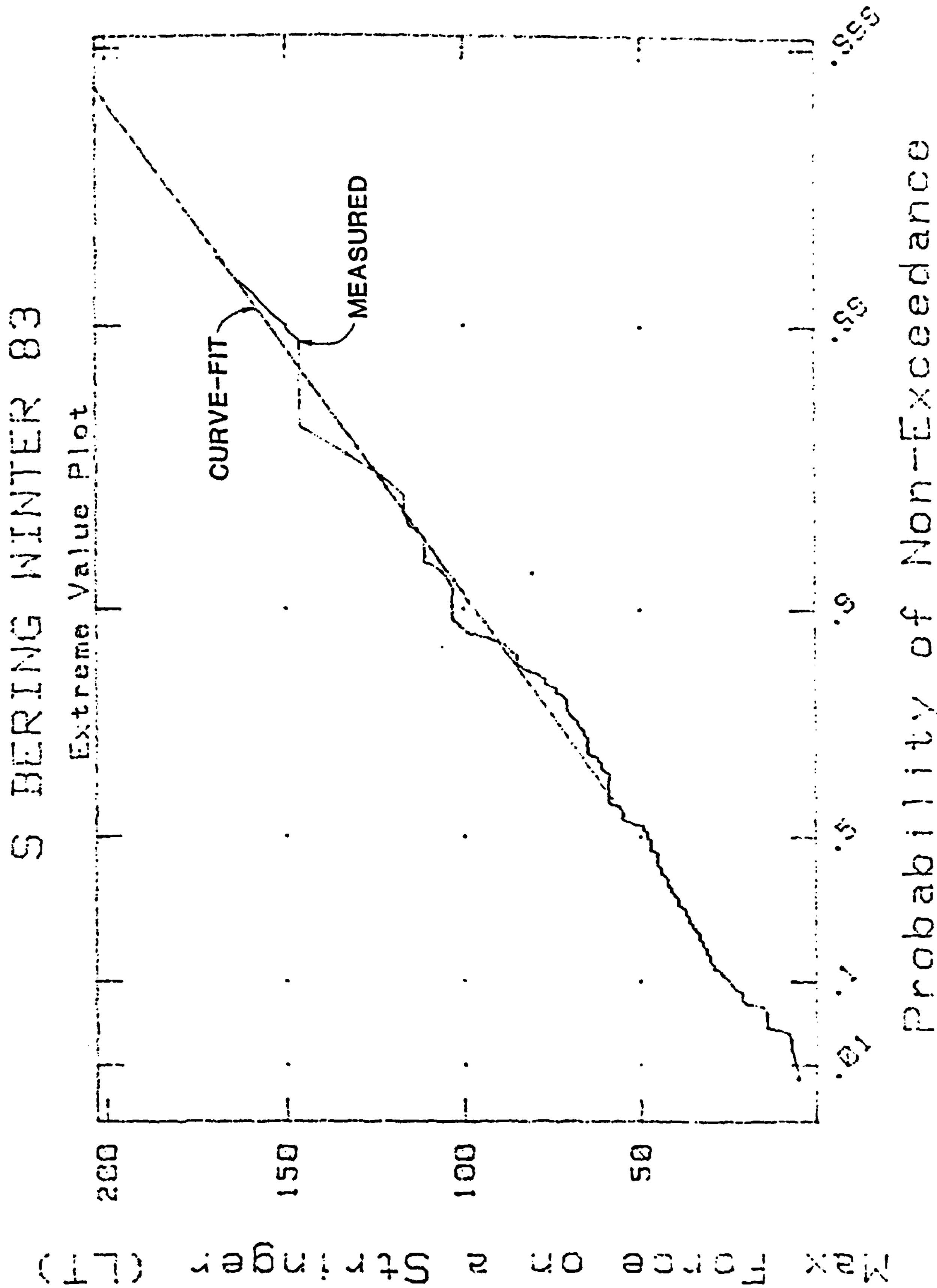
S BERING SEA WINTER 83
Extreme Value Plot
Max 1 Sub-panel Pres (psi)
1000
500
Probability of Non-Exceedance
.01
.1
.5
.9
.99
.995
MEASURED
CURVE-FIT

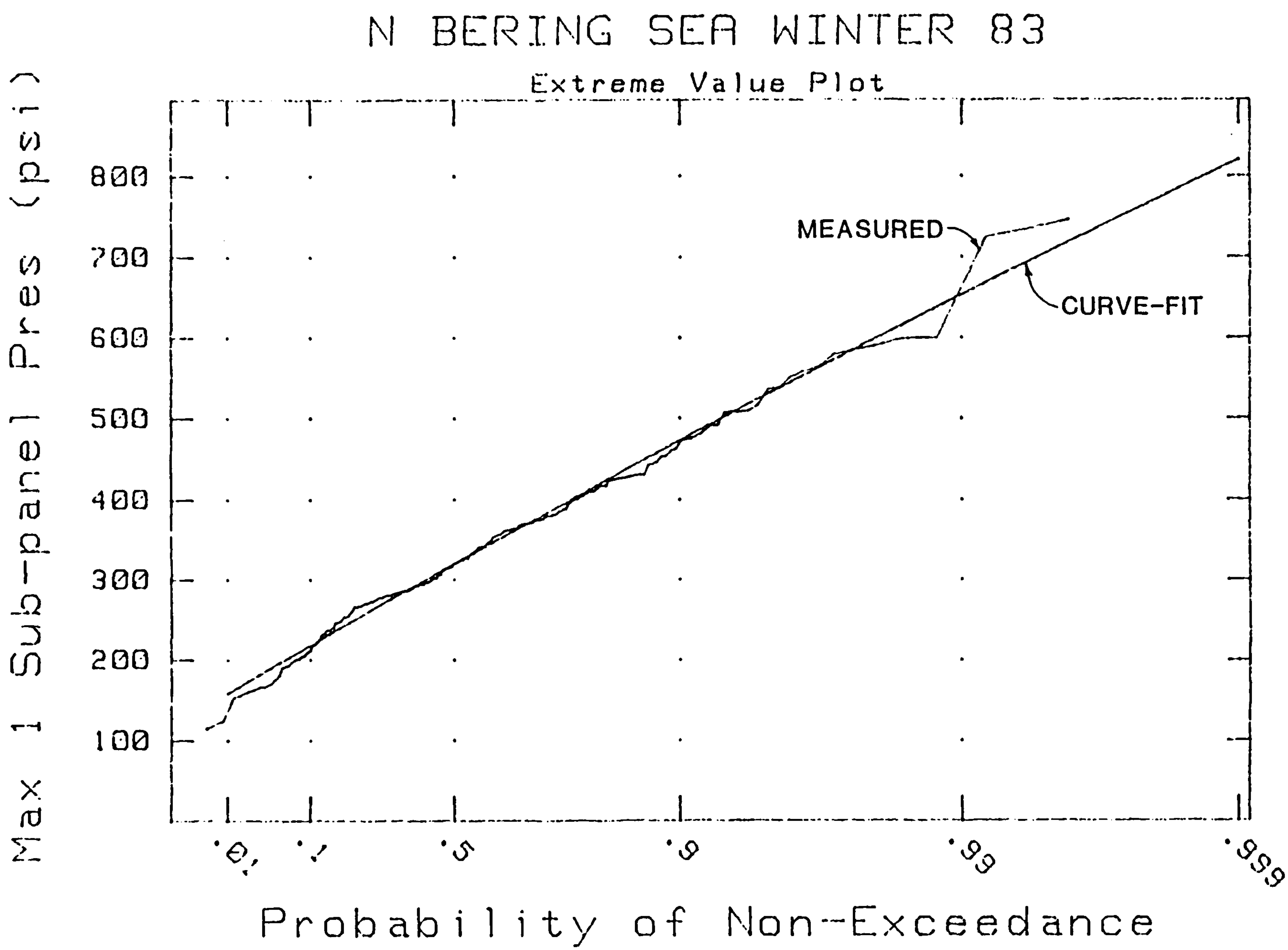

S BERING WINTER 83
Extreme Value Plot
MEASURED
CURVE-FIT
500
400
300
200
100
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max 4 Sub-panel Pres (psi)

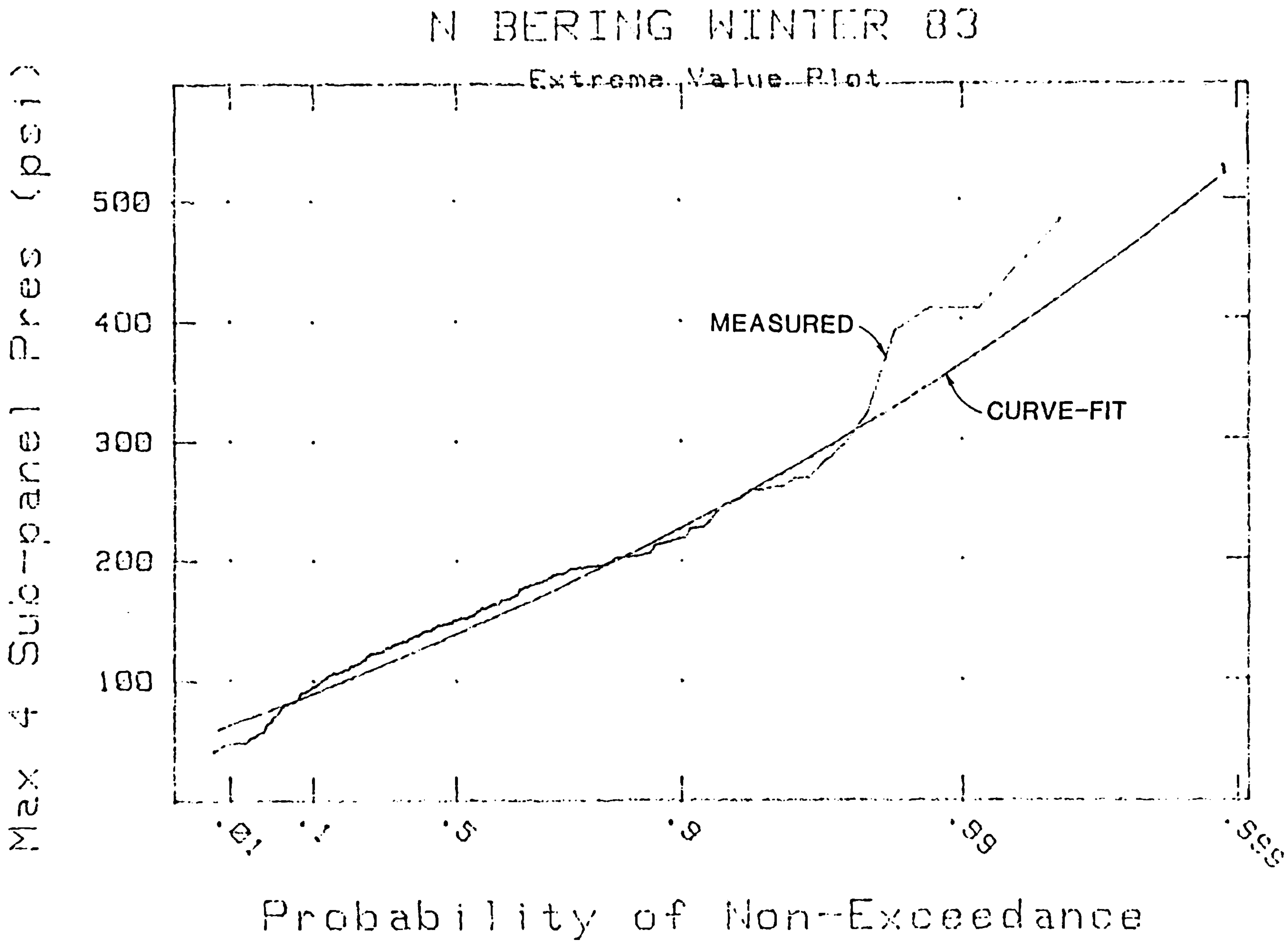

S BERING WINTER 83
Extreme Value Plot
CURVE-FIT
MEASURED
Total Force on Panel (LT)
300
250
200
150
100
50
Probability of Non-Exceedance
.01
.1
.5
.9
.99
.999

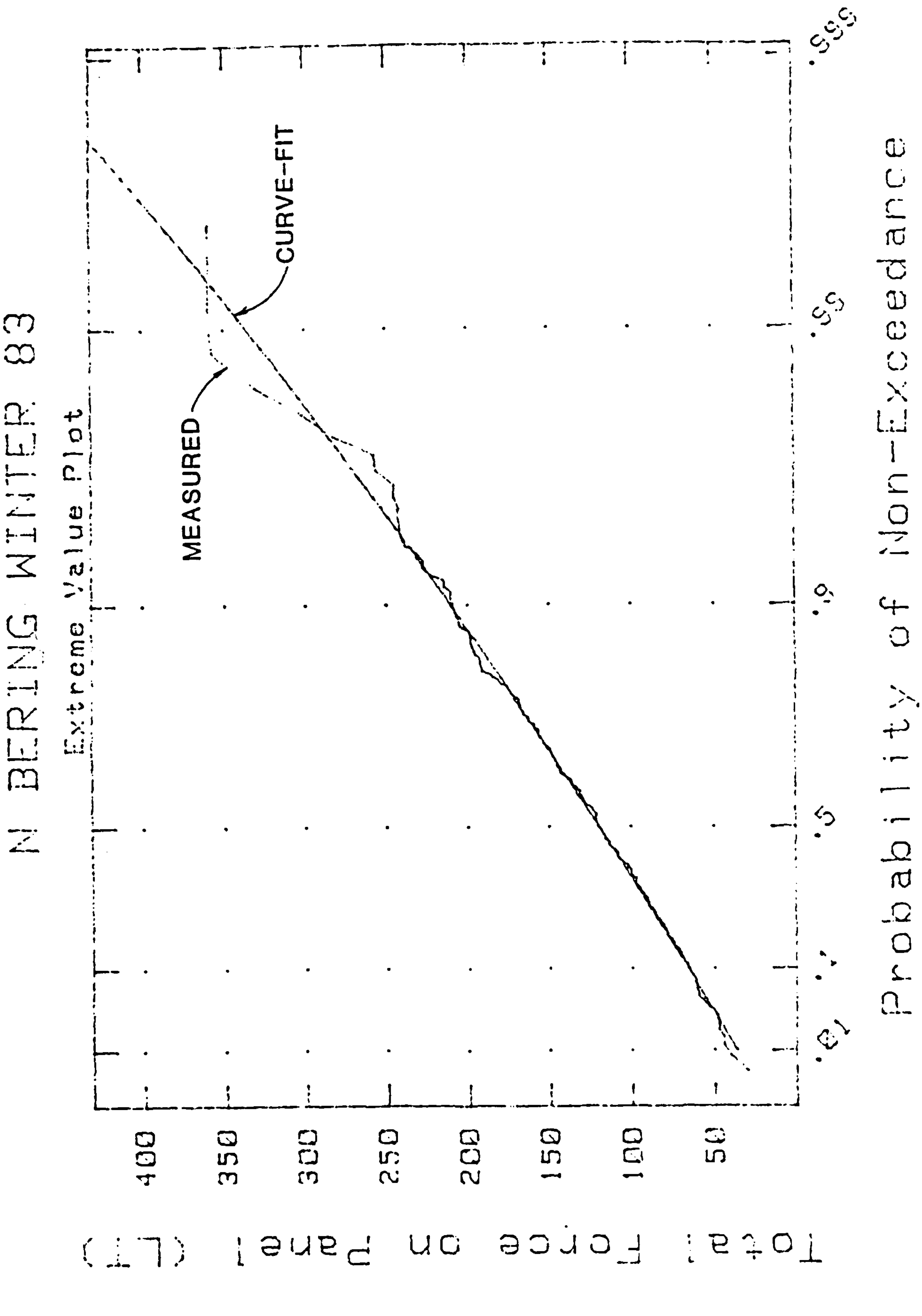


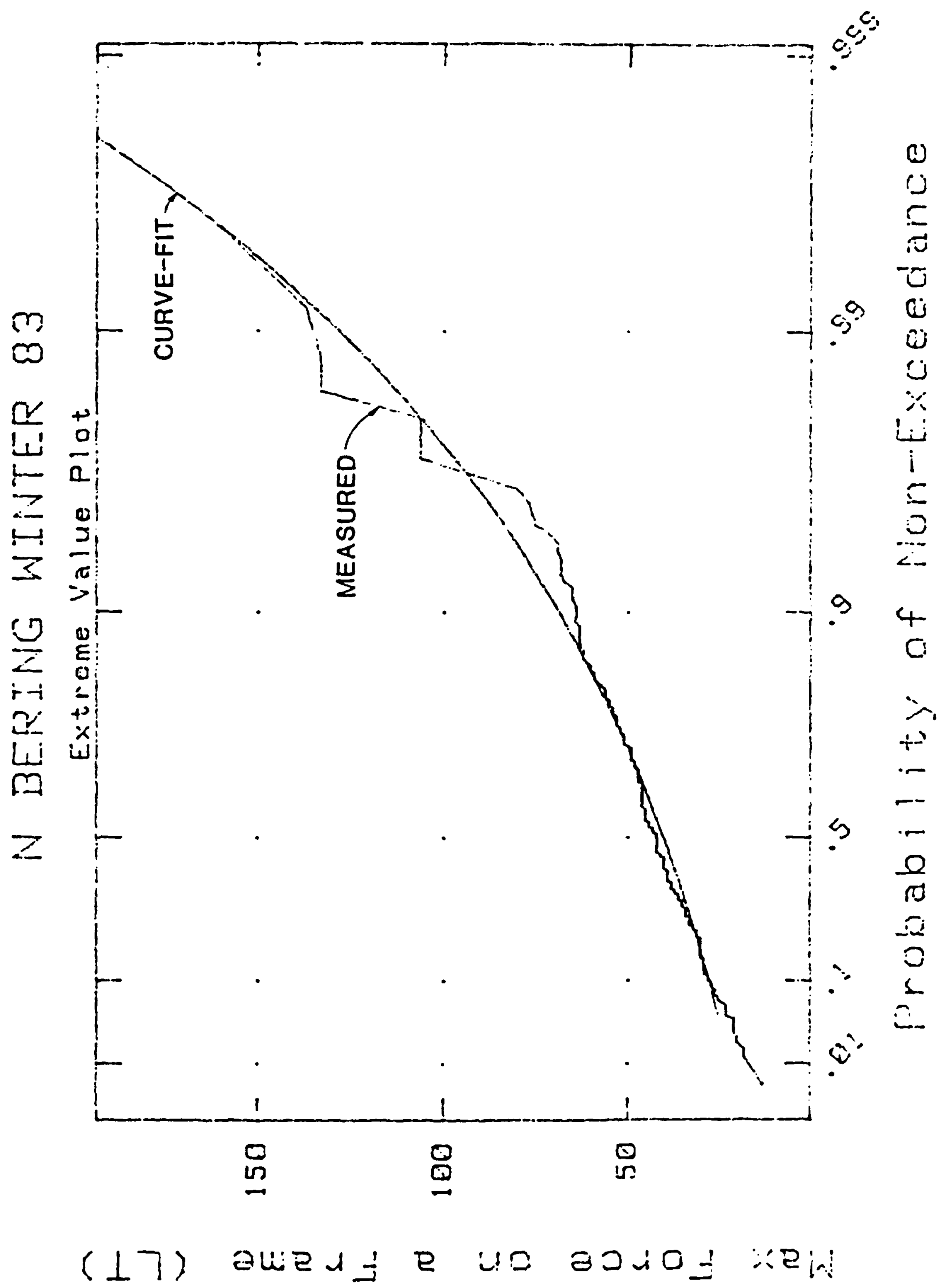
S BERING WINTER 83
Extreme Value Plot
CURVE-FIT
MEASURED
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max Force on a Frame (LT)


S BERING WINTER 83
Extreme Value Plot
MEASURED
CURVE-FIT
200
150
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max Force on a Stringer (LT)

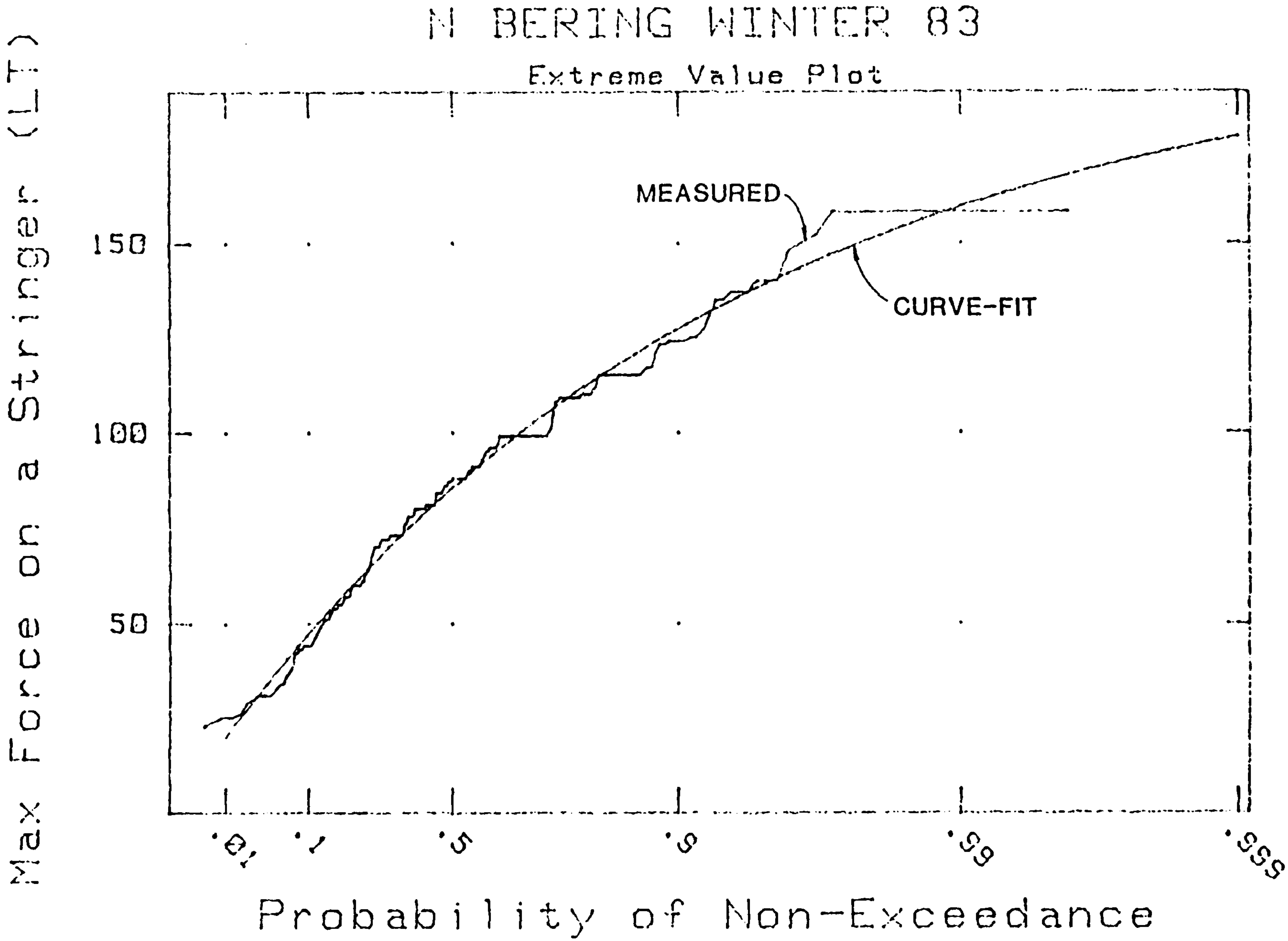

N BERING SEA WINTER 83
Extreme Value Plot
MEASURED
CURVE-FIT
800
700
600
500
400
300
200
100
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max 1 Sub-panel Pres (psi)

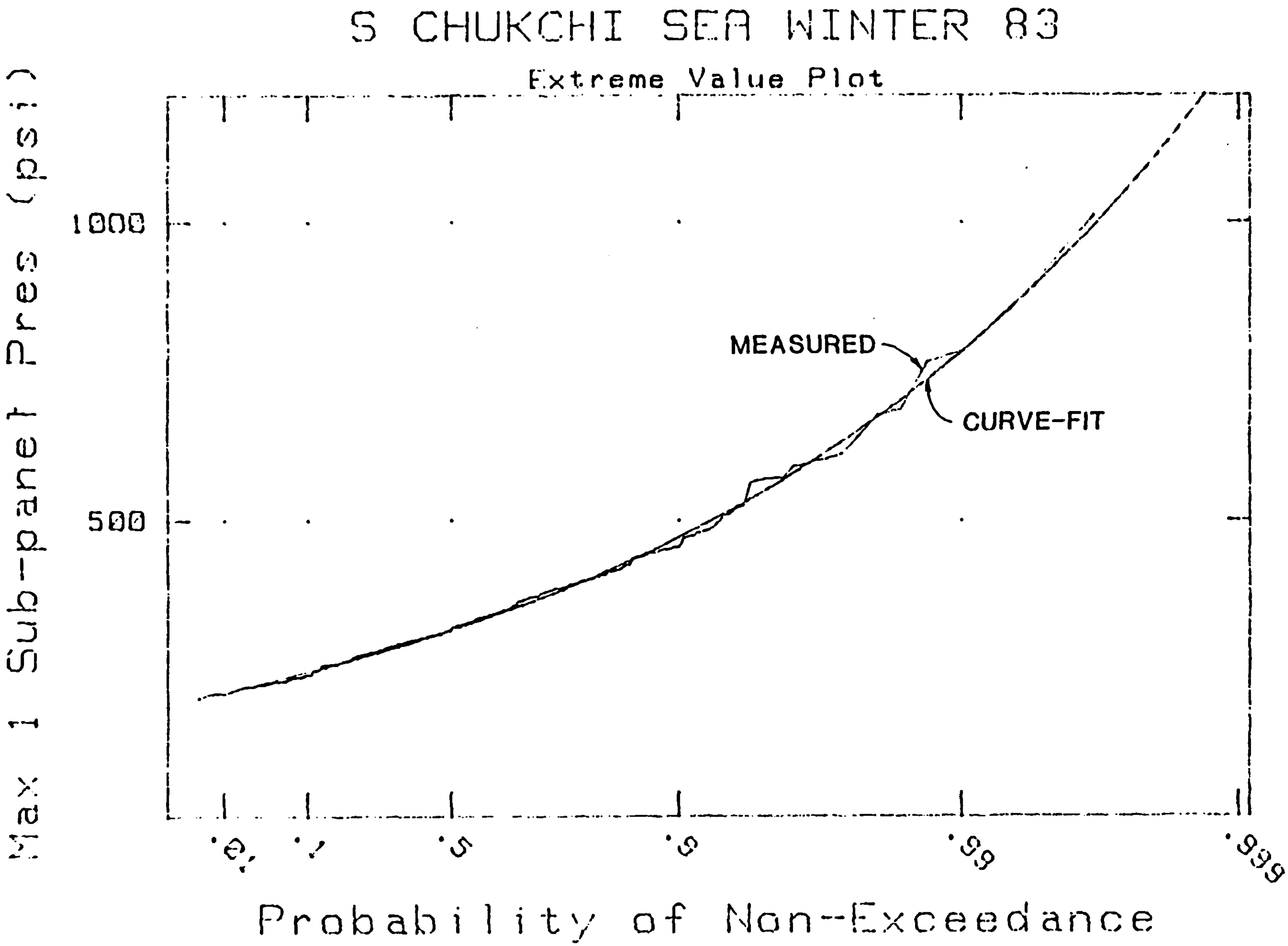

N BERING WINTER 83
Extreme Value Plot
Max 4 Sub-panel Pres (psi)
500
400
300
200
100
MEASURED
CURVE-FIT
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

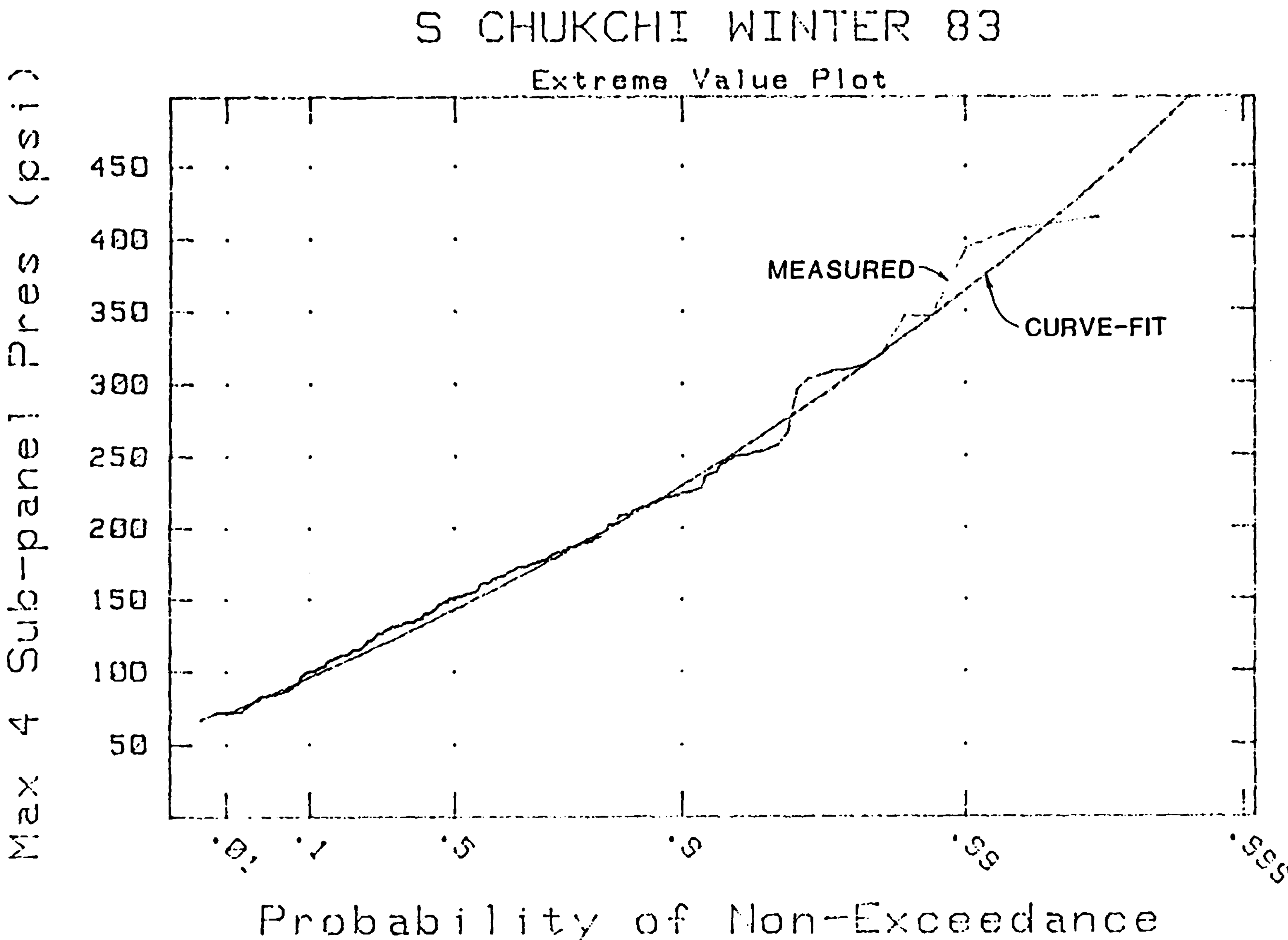

N BERING WINTER 83
Extreme Value Plot
CURVE-FIT
MEASURED
Total Force on Panel (LT)
400
350
300
250
200
150
100
50
Probability of Non-Exceedance
.01
.1
.5
.9
.99
.999

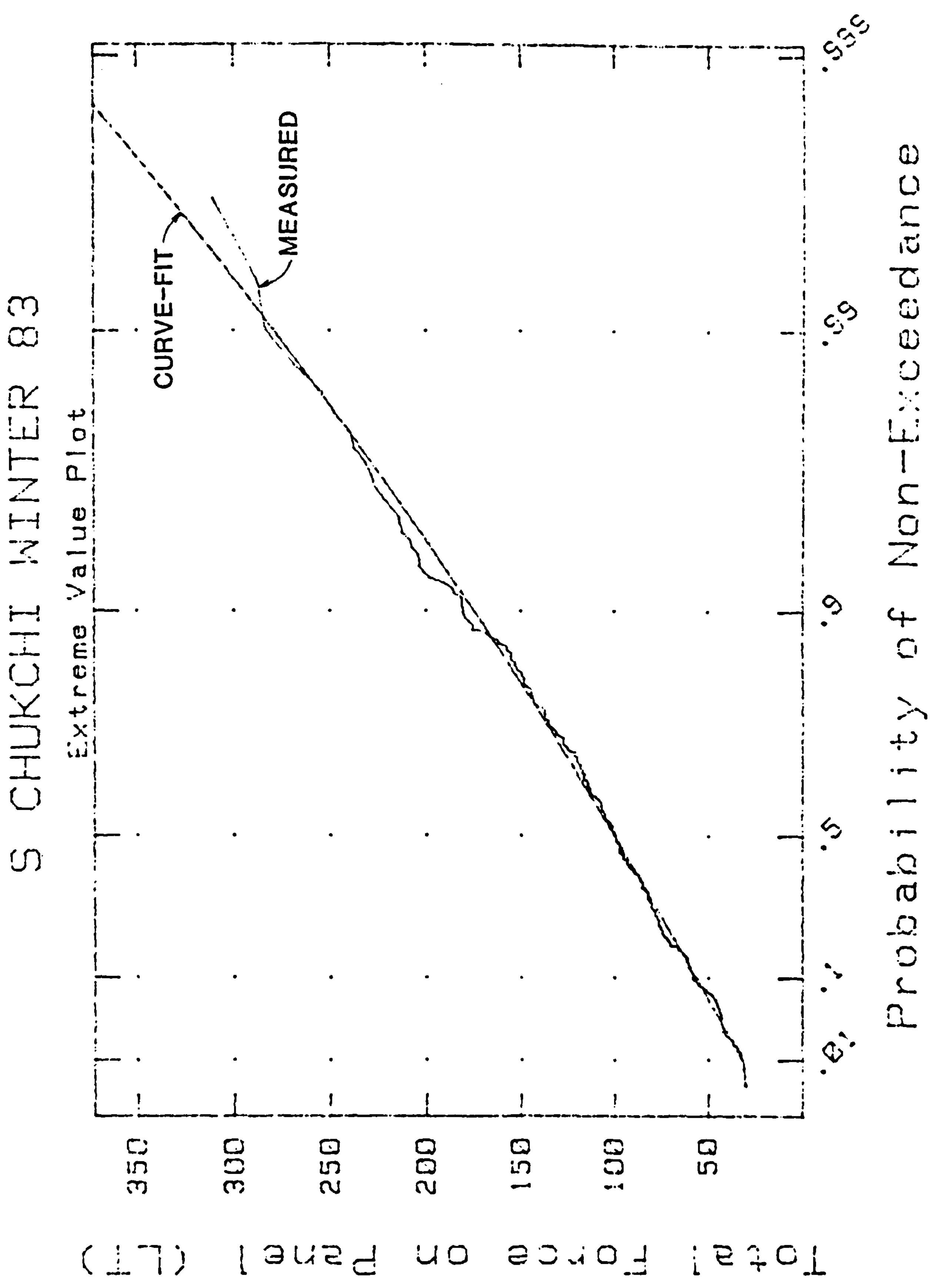


N BERING WINTER 83
Extreme Value Plot
CURVE-FIT
MEASURED
150
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max Force on a Frame (LT)

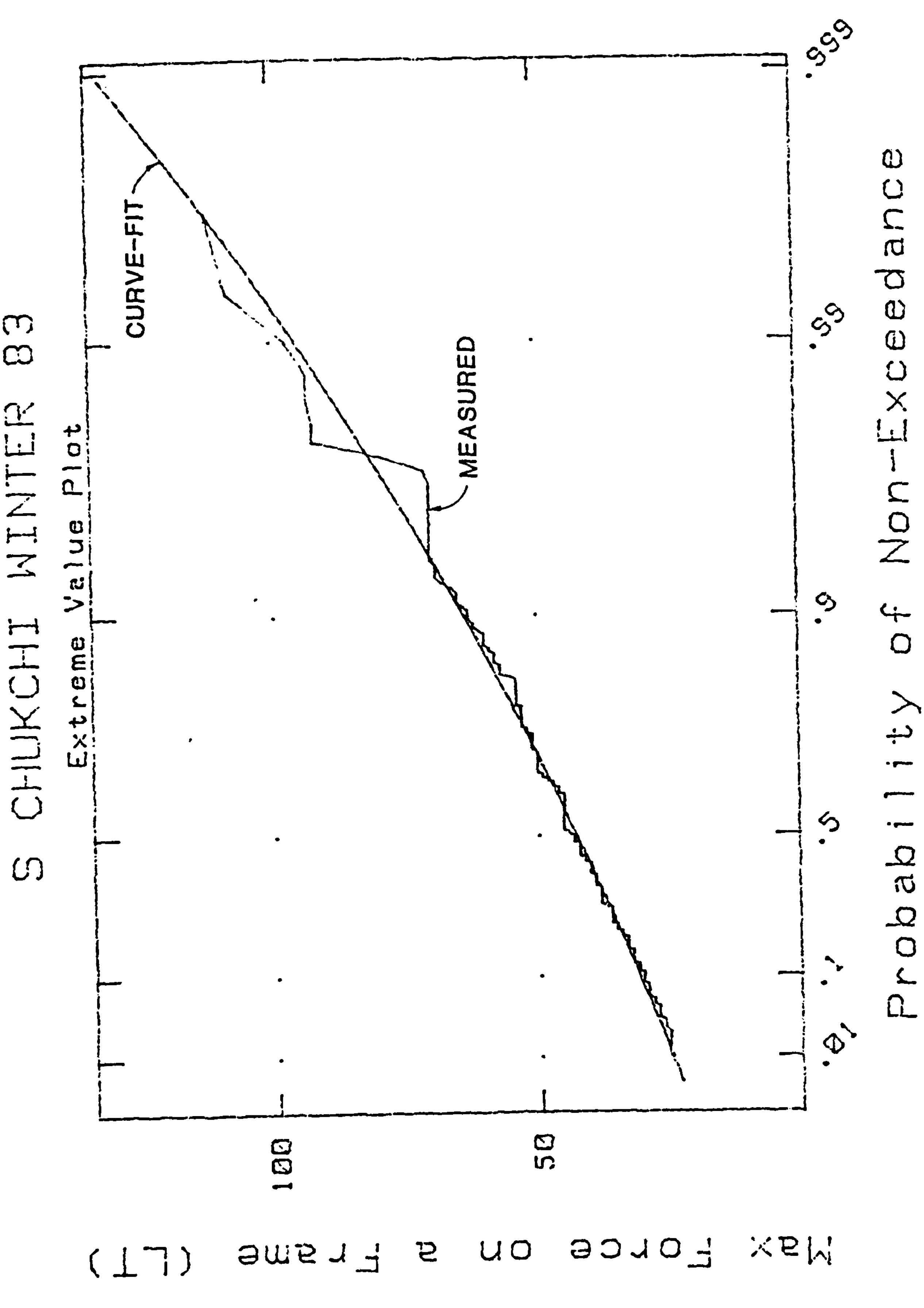

N BERING WINTER 83
Extreme Value Plot
MEASURED
CURVE-FIT
150
100
50
.01
.1
.5
.9
.99
.999
Max Force on a Stringer (LT)
Probability of Non-Exceedance

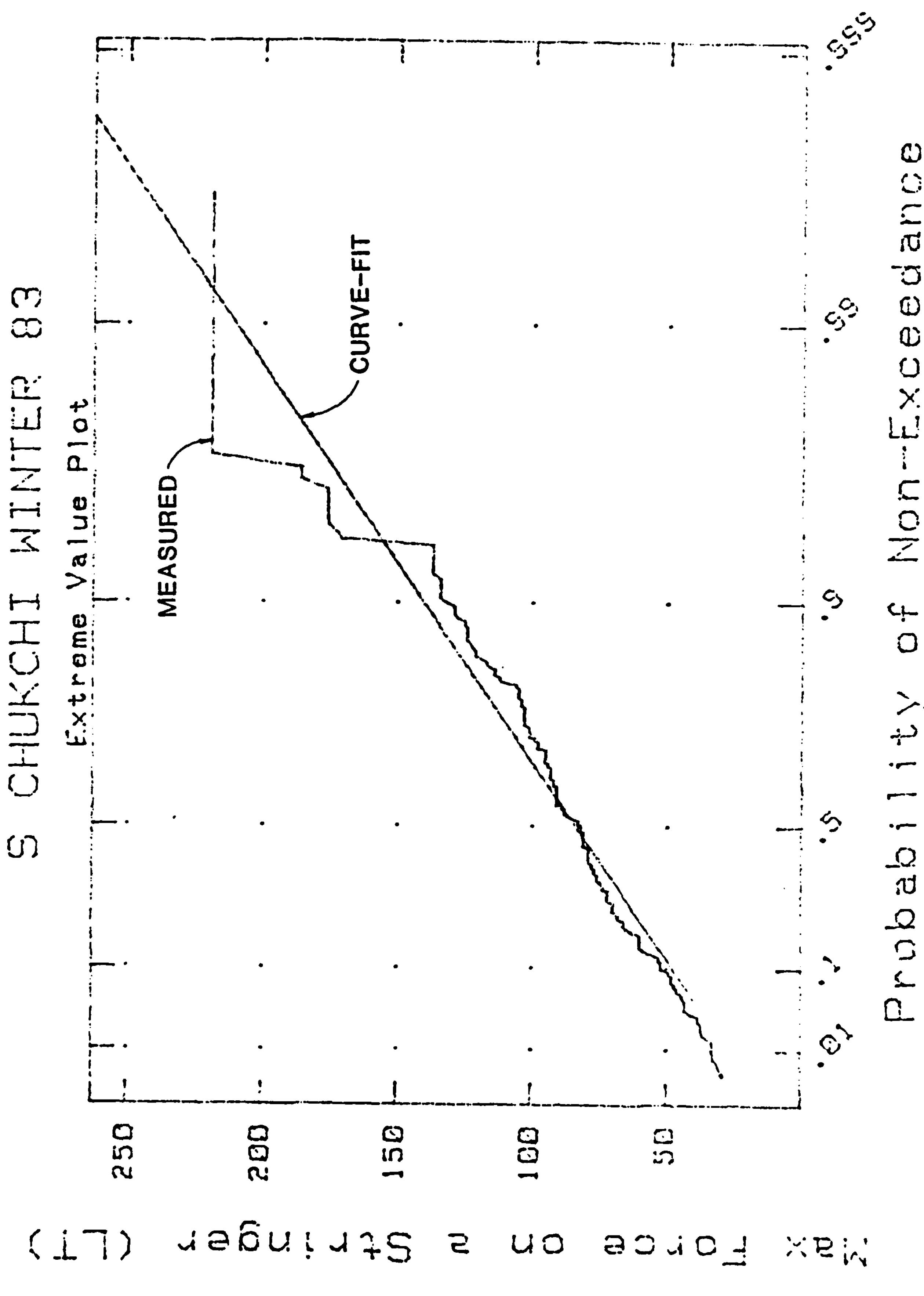

S CHUKCHI SEA WINTER 83
Extreme Value Plot
Max 1 Sub-panel Pres (psi)
1000
500
MEASURED
CURVE-FIT
.5
.9
.99
.999
Probability of Non-Exceedance

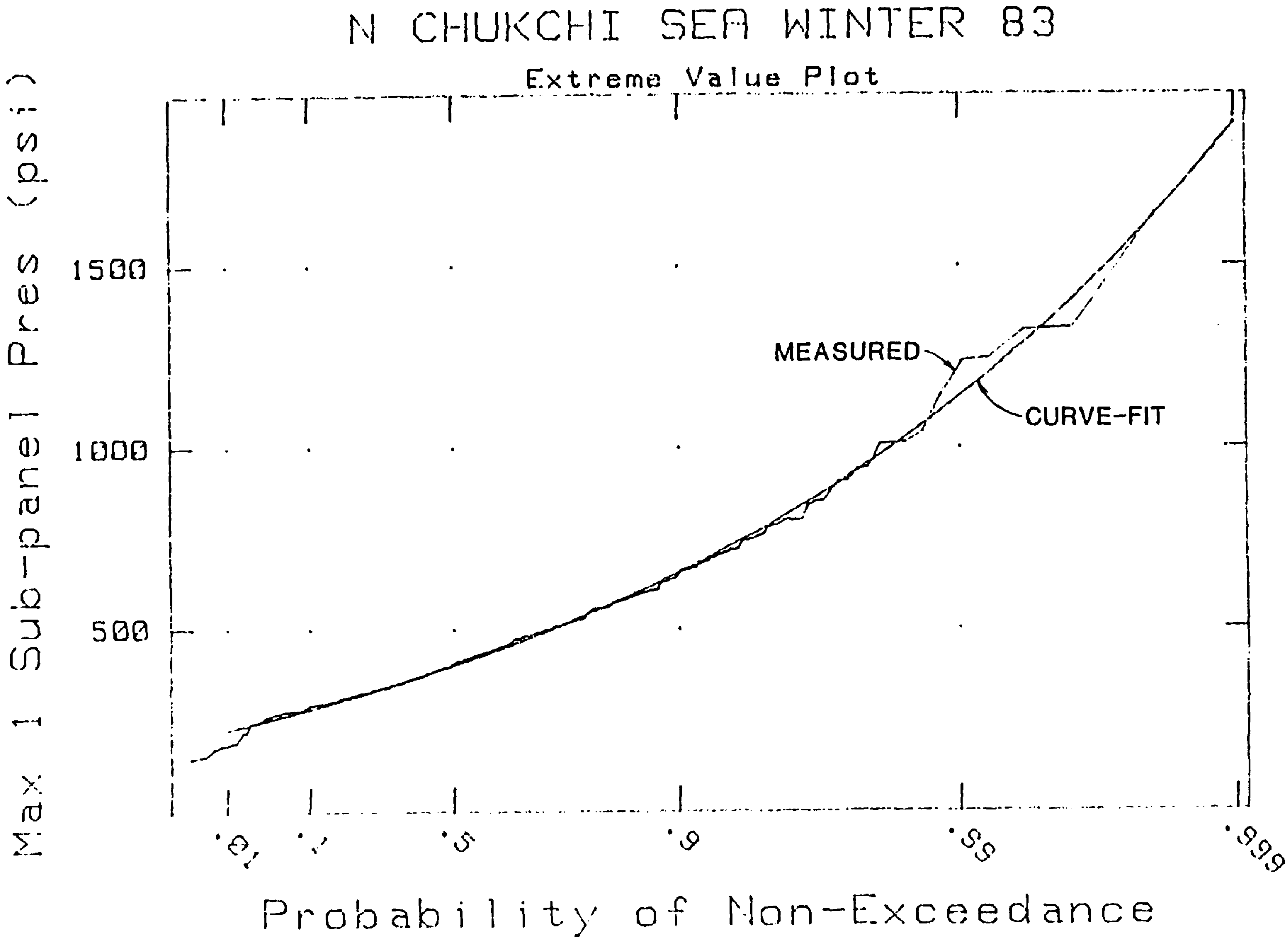

S CHUKCHI WINTER 83
Extreme Value Plot
Max 4 Sub-panel Pres (psi)
450
400
350
300
250
200
150
100
50
MEASURED
CURVE-FIT
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

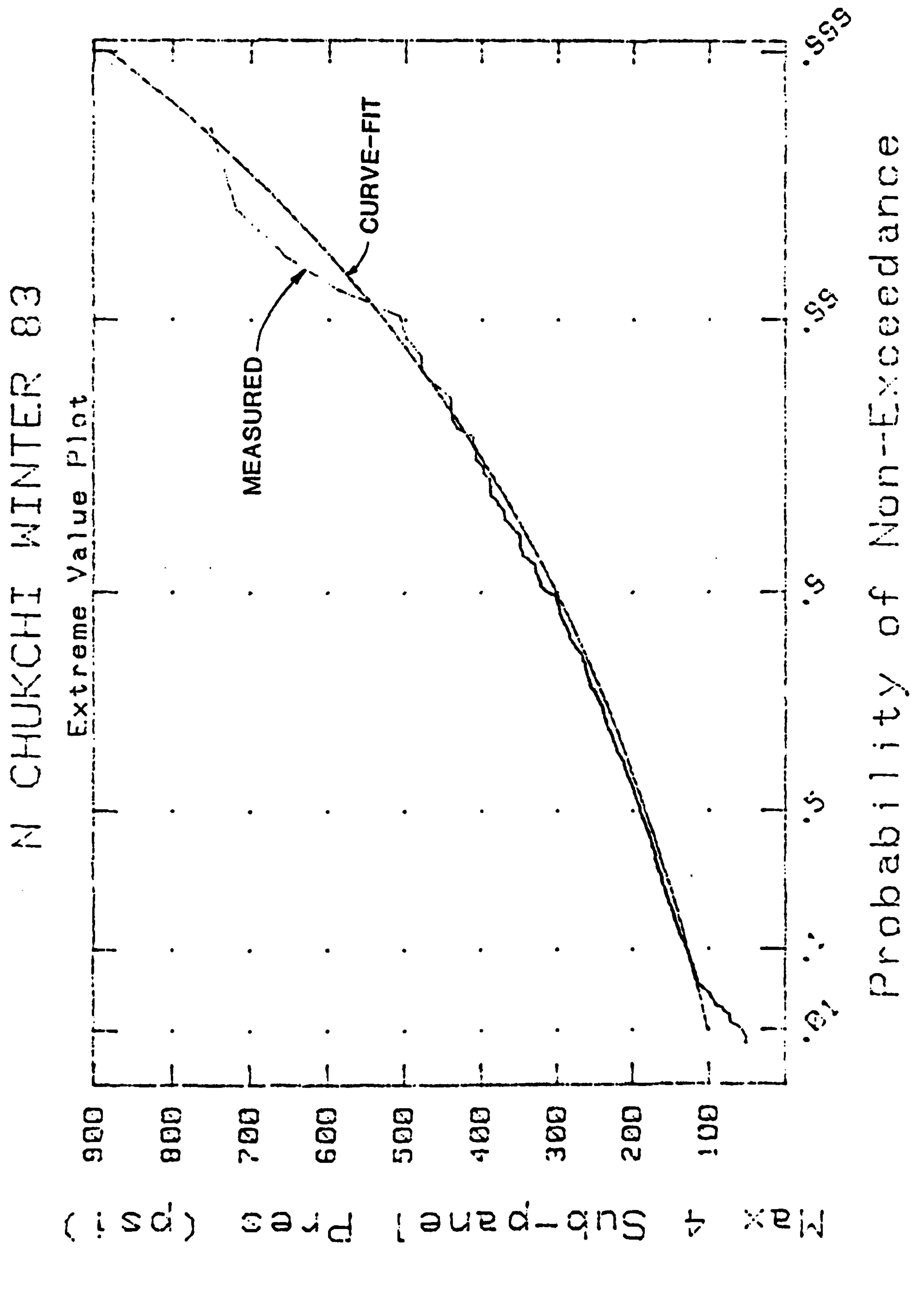


S CHUKCHI WINTER 83
Extreme Value Plot
CURVE-FIT
MEASURED
350
300
250
200
150
100
50
.01
.5
.9
.99
.999
Total Force on Panel (LT)
Probability of Non-Exceedance

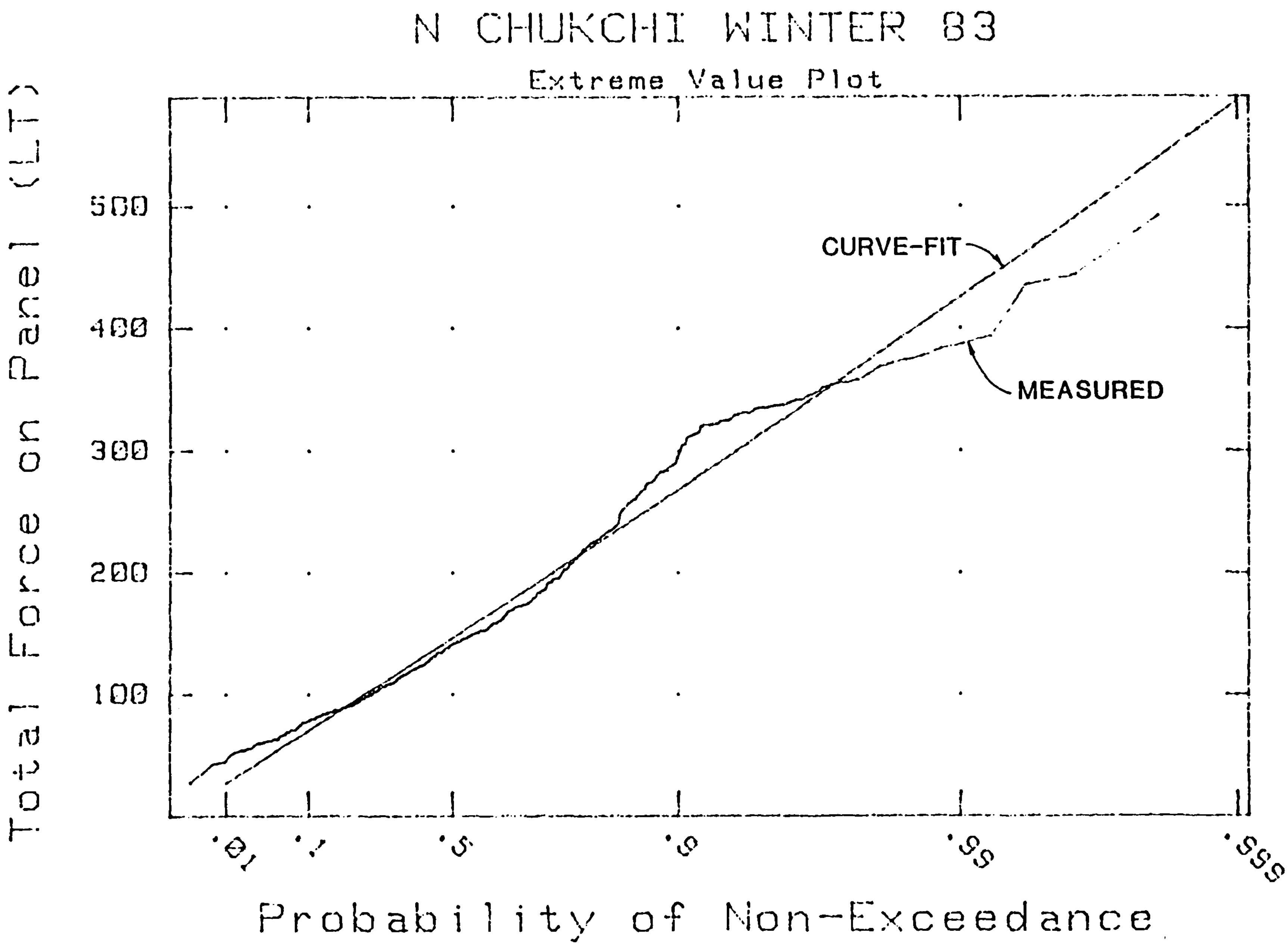

S CHUKCHI WINTER 83
Extreme Value Plot
CURVE-FIT
MEASURED
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max Force on a Frame (LT)

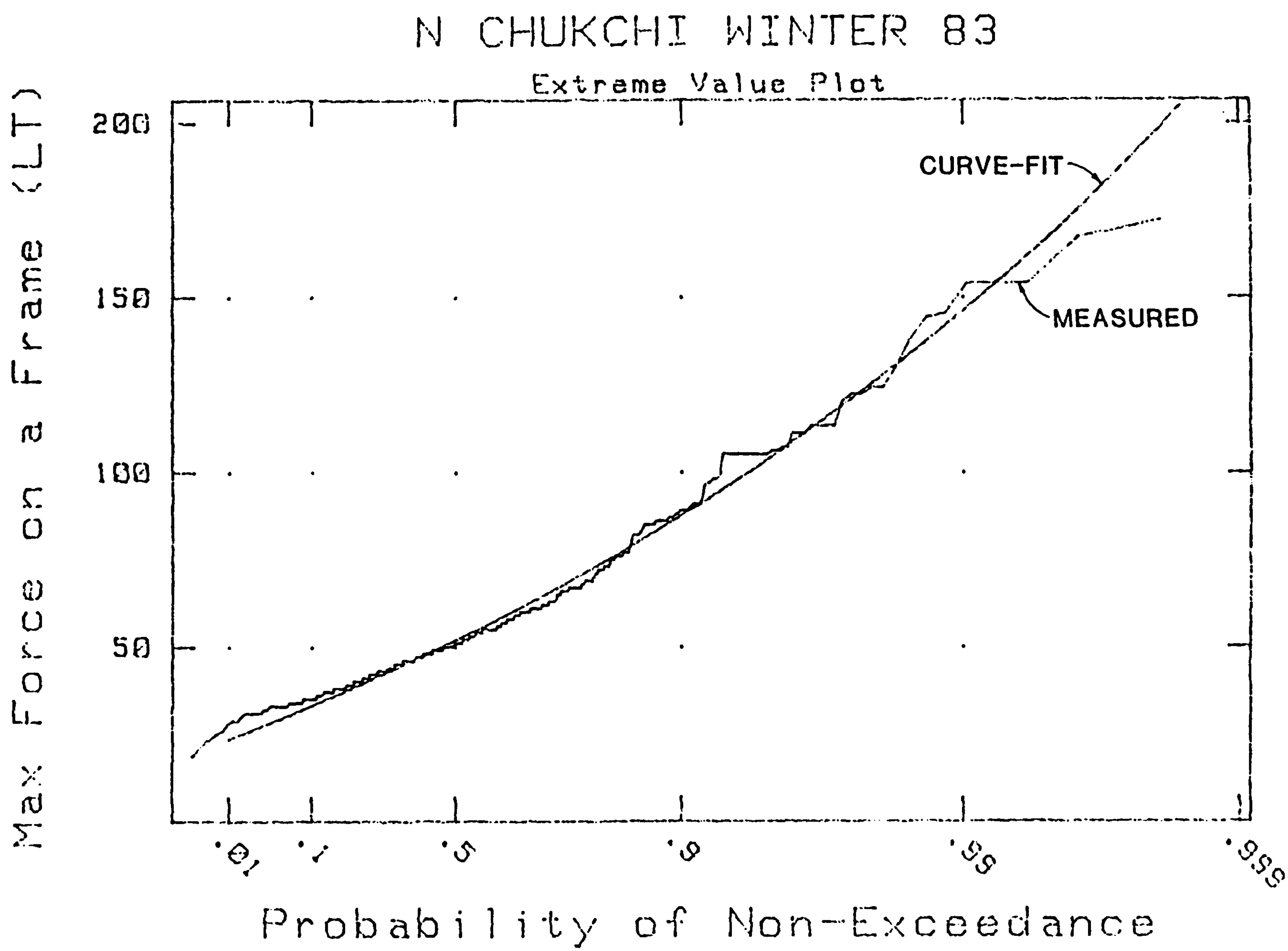

S CHUKCHI WINTER 83
Extreme Value Plot
MEASURED
CURVE-FIT
Max Force on a Stringer (LT)
250
200
150
100
50
Probability of Non-Exceedance
.01
.1
.5
.9
.99
.999


N CHUKCHI SEA WINTER 83
Extreme Value Plot
Max 1 Sub-panel Pres (psi)
1500
1000
500
MEASURED
CURVE-FIT
.01
.5
.9
.99
.999
Probability of Non-Exceedance

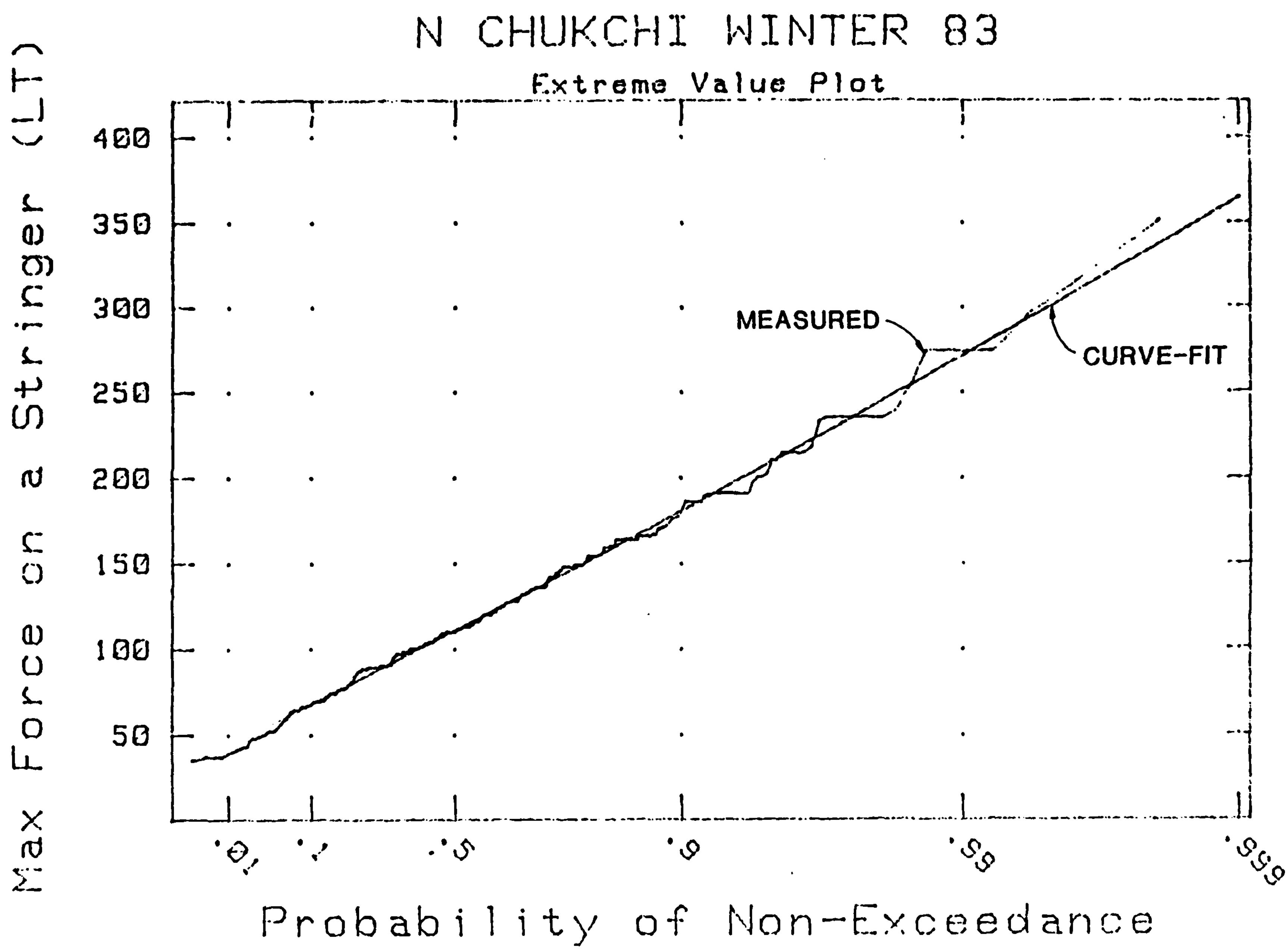


N CHUKCHI WINTER 83
Extreme Value Plot
Max 4 Sub-panel Pres (psi)
900
800
700
600
500
400
300
200
100
Probability of Non-Exceedance
.01
.5
.9
.99
.999
MEASURED
CURVE-FIT

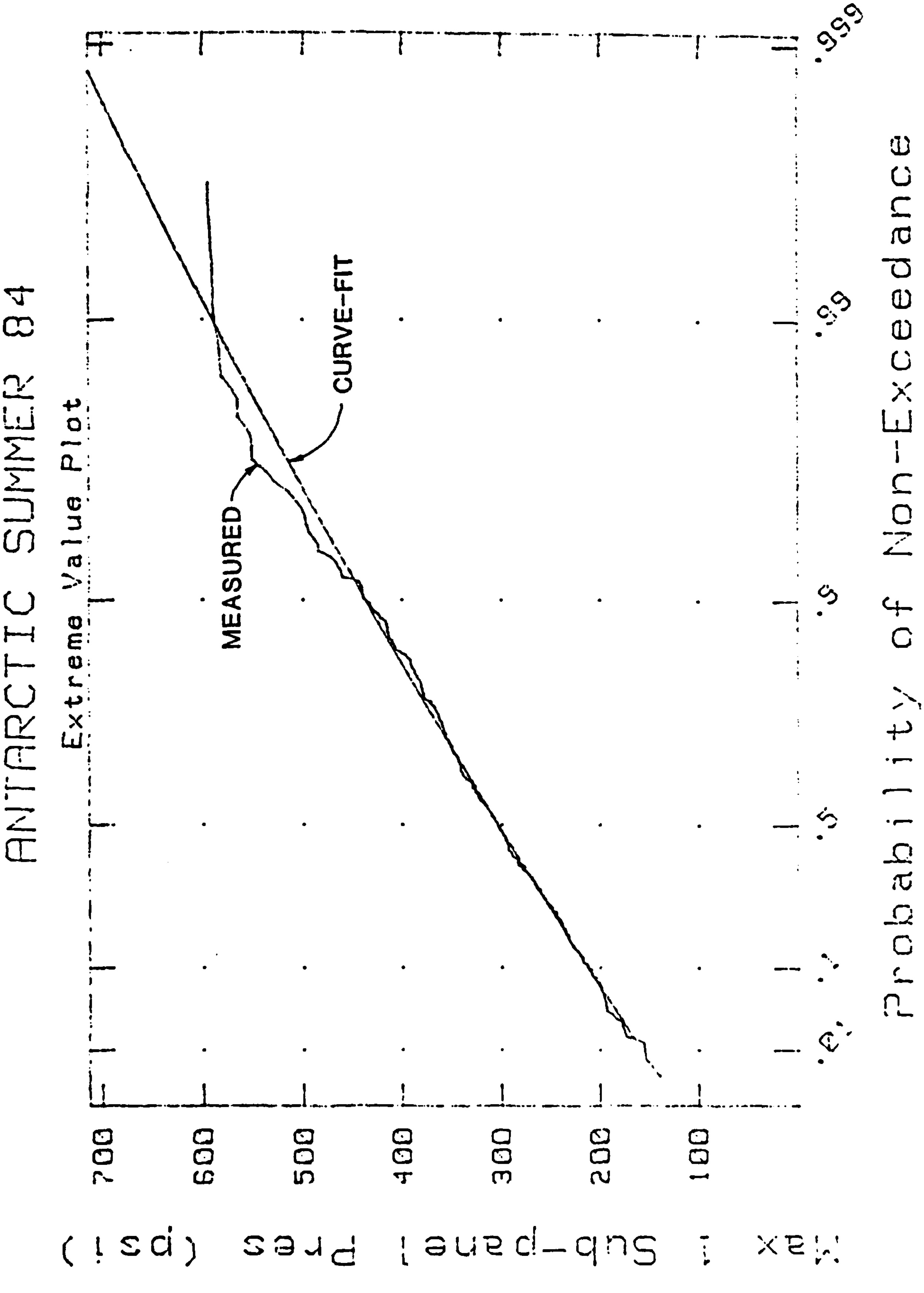

N CHUKCHI WINTER 83
Extreme Value Plot
Total Force on Panel (LT)
500
400
300
200
100
CURVE-FIT
MEASURED
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance



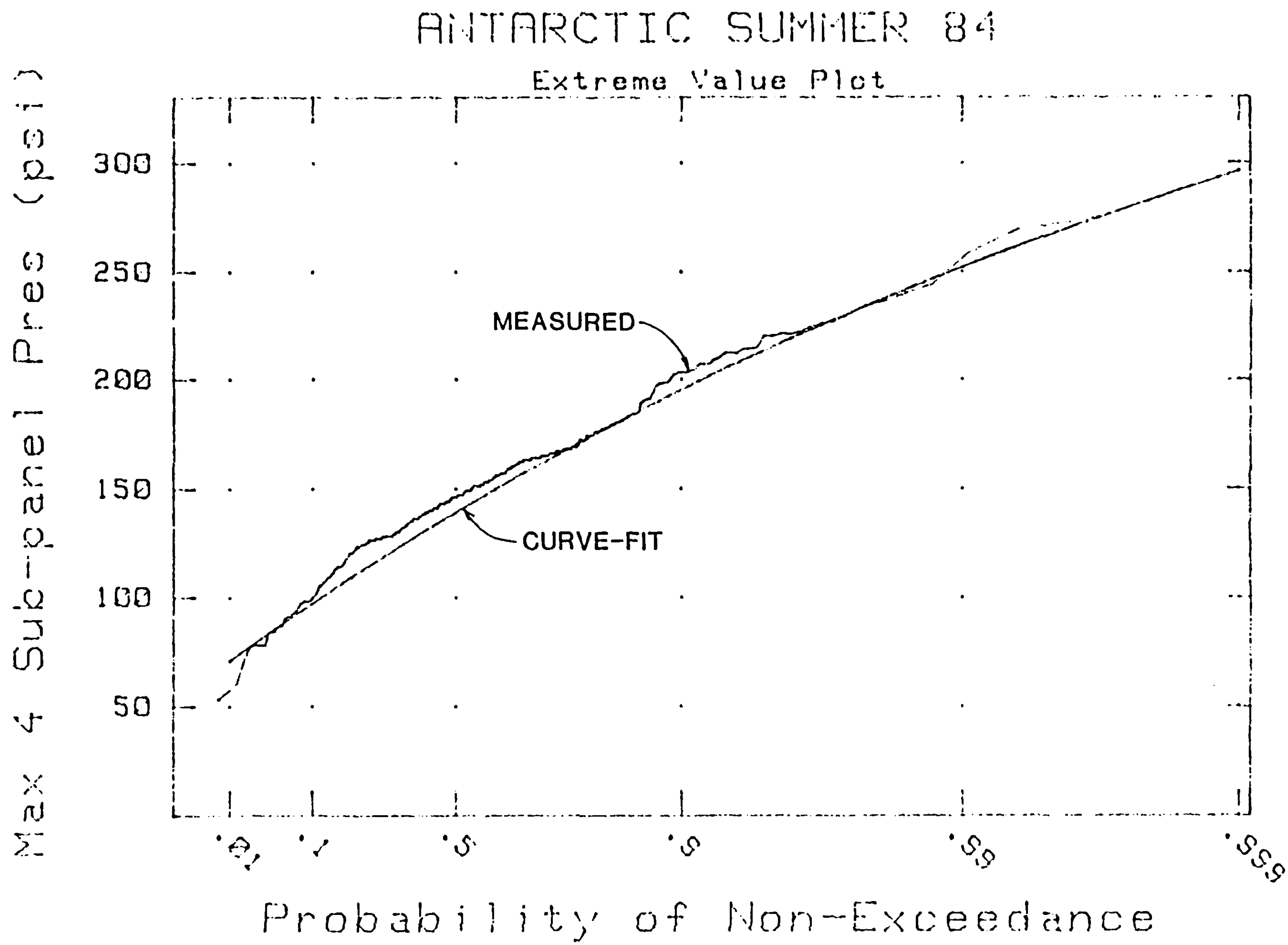
N CHUKCHI WINTER 83
Extreme Value Plot
CURVE-FIT
MEASURED
200
150
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max Force on a Frame (LT)

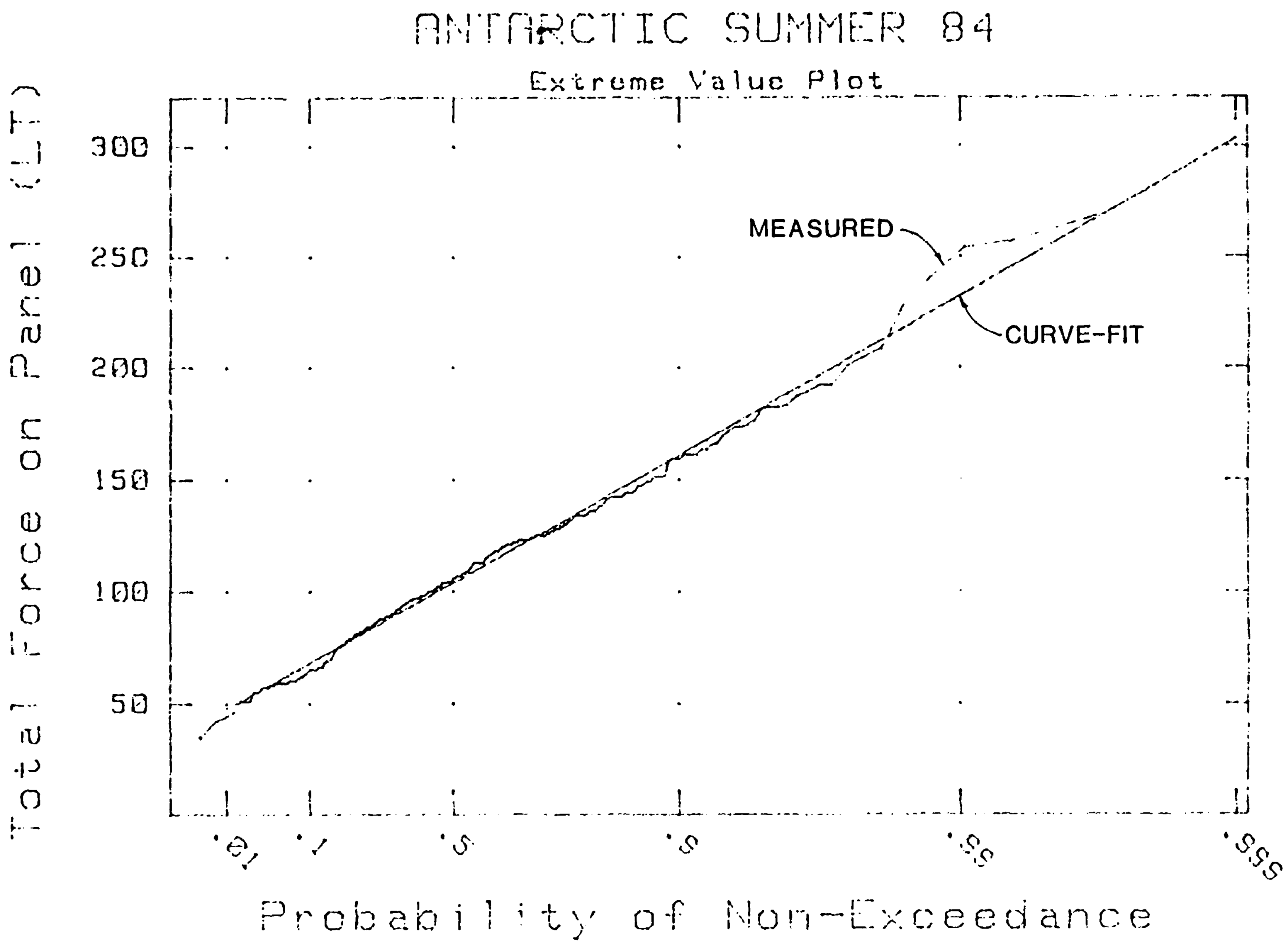


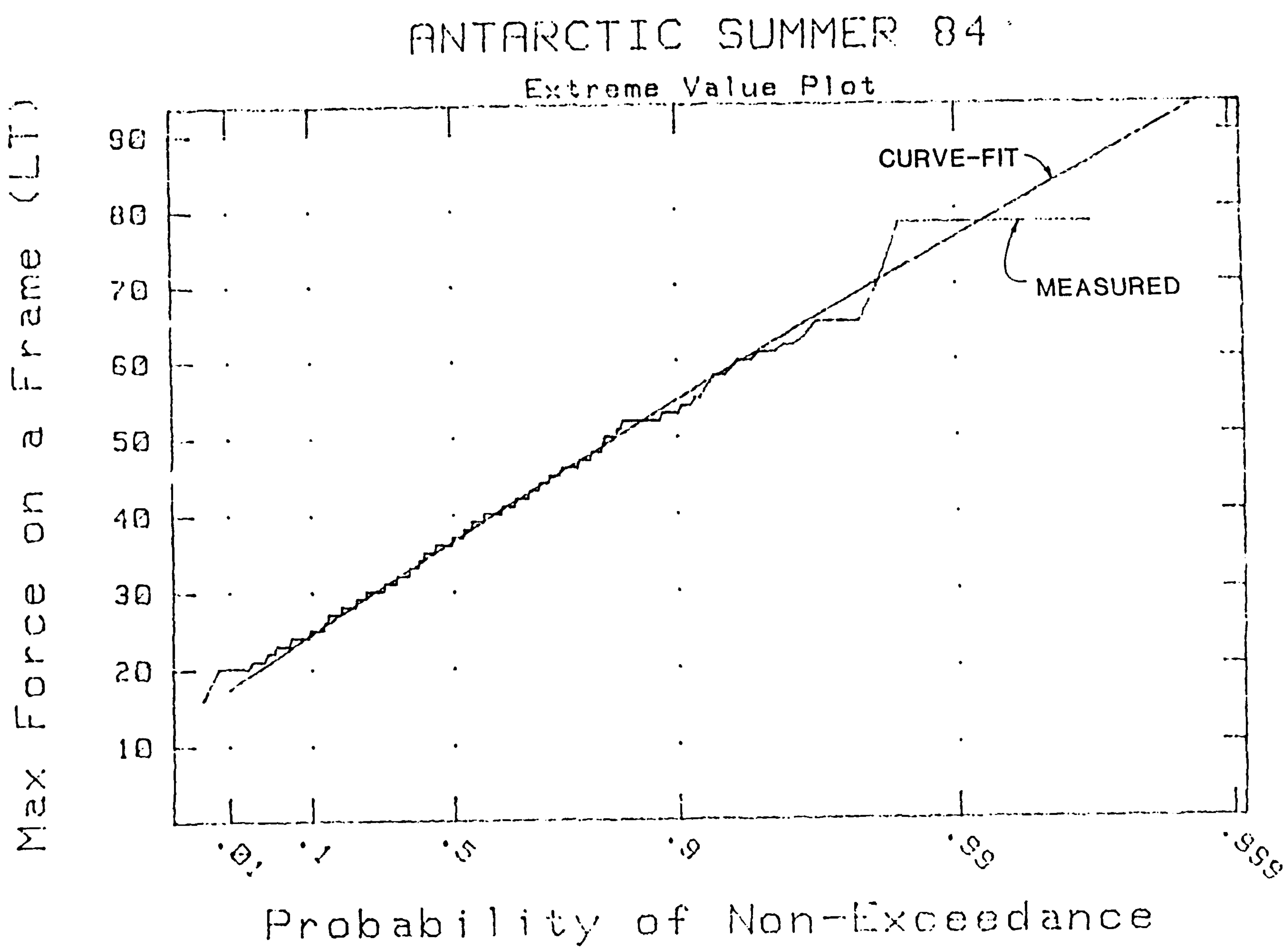
N CHUKCHI WINTER 83
Extreme Value Plot
Max Force on a Stringer (LT)
400
350
300
250
200
150
100
50
MEASURED
CURVE-FIT
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

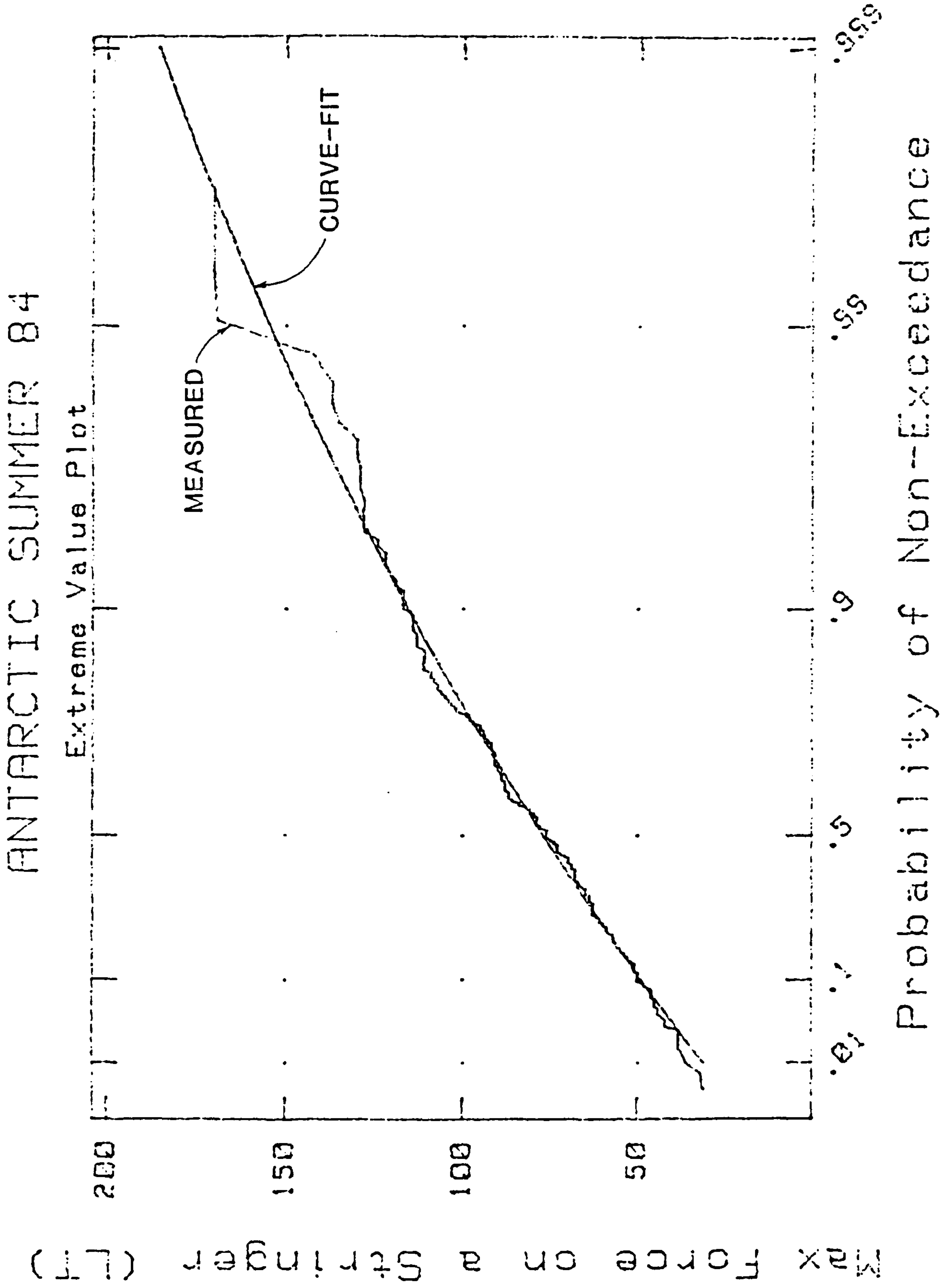


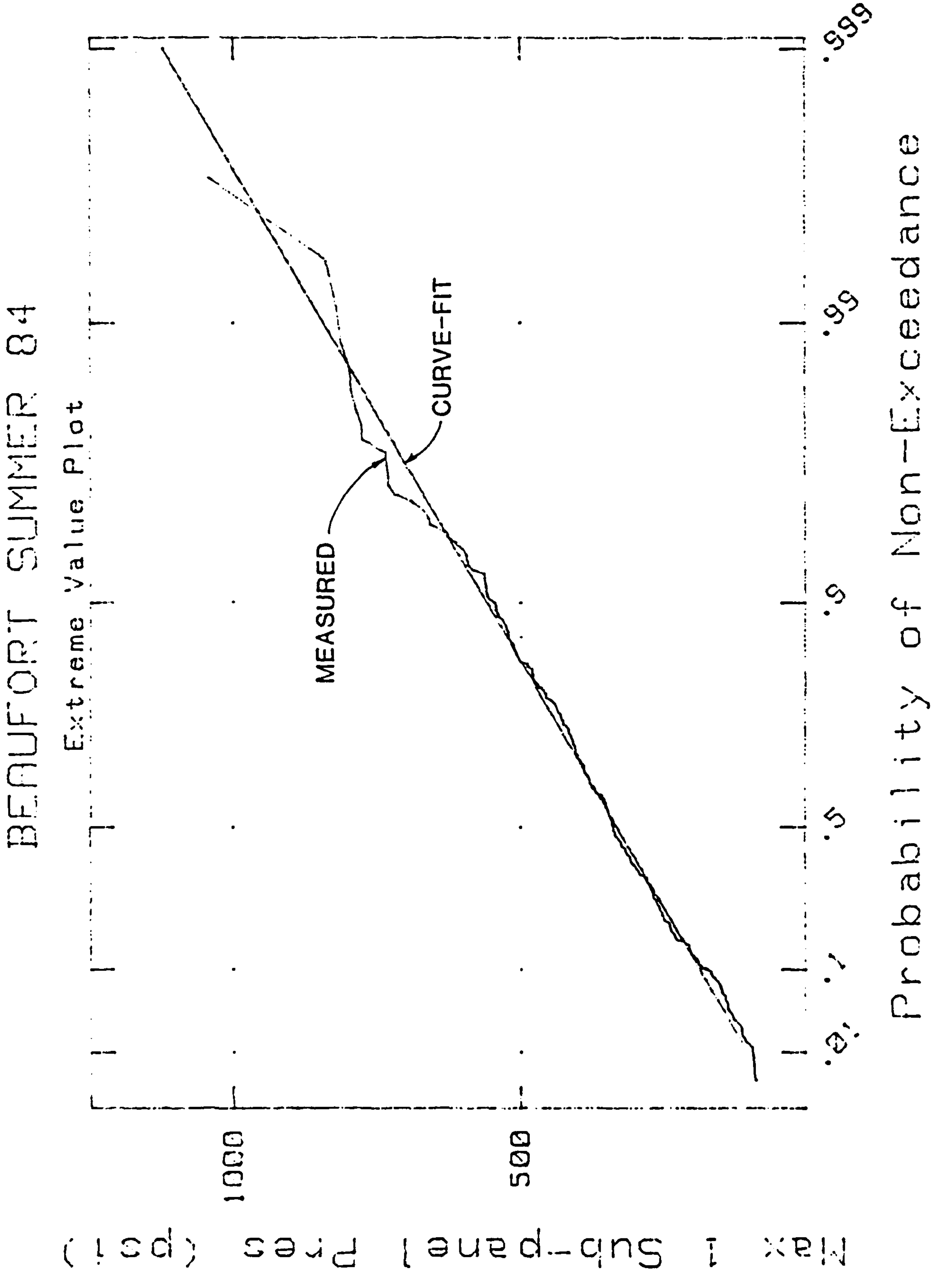
ANTARCTIC SUMMER 84
Extreme Value Plot
Max 1 Sub-panel Pres (psi)
700
600
500
400
300
200
100
MEASURED
CURVE-FIT
Probability of Non-Exceedance
.999
.99
.9
.5

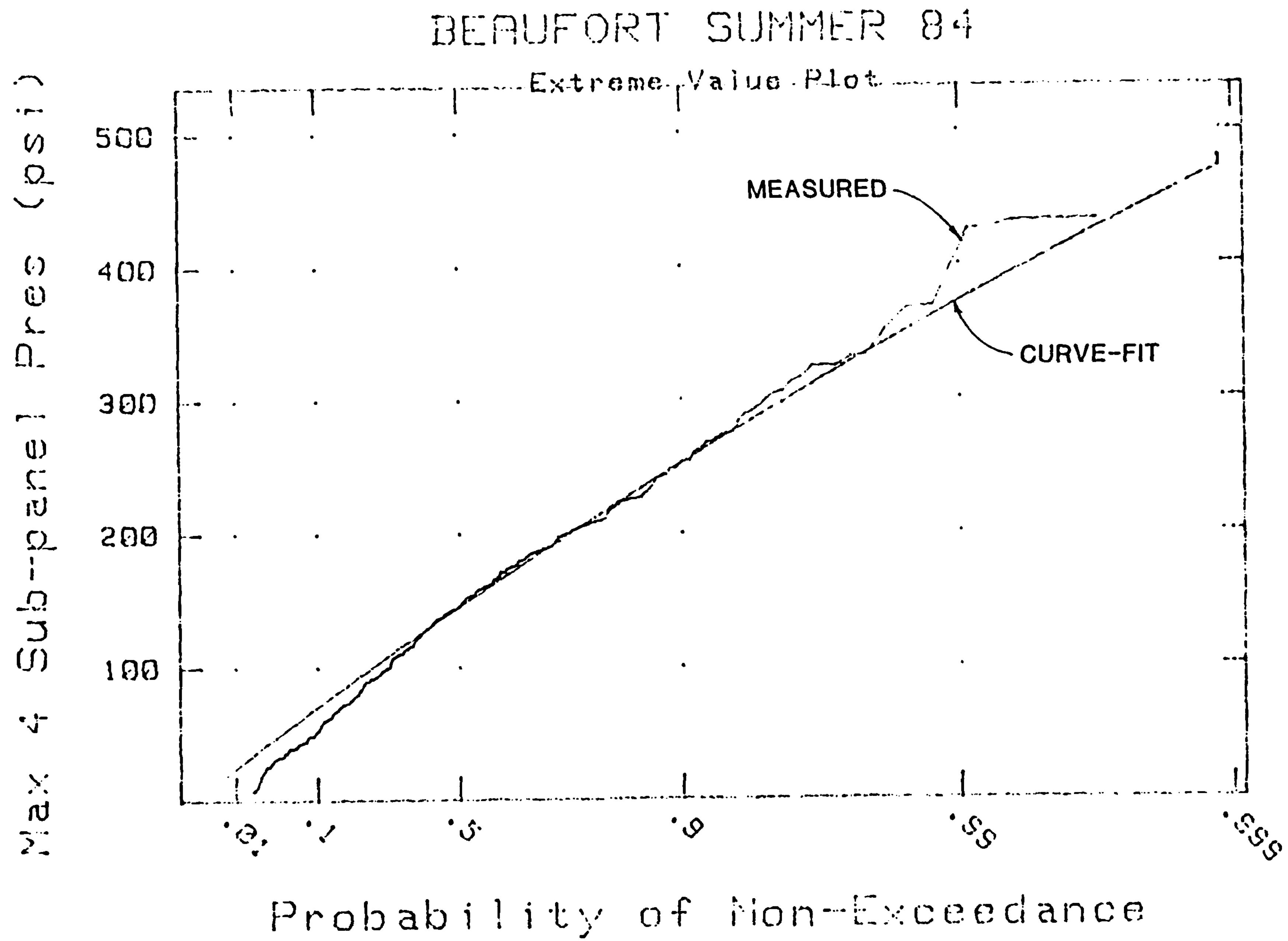

ANTARCTIC SUMMER 84
Extreme Value Plot
Max 4 Sub-panel Pres (psi)
300
250
200
150
100
50
MEASURED
CURVE-FIT
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

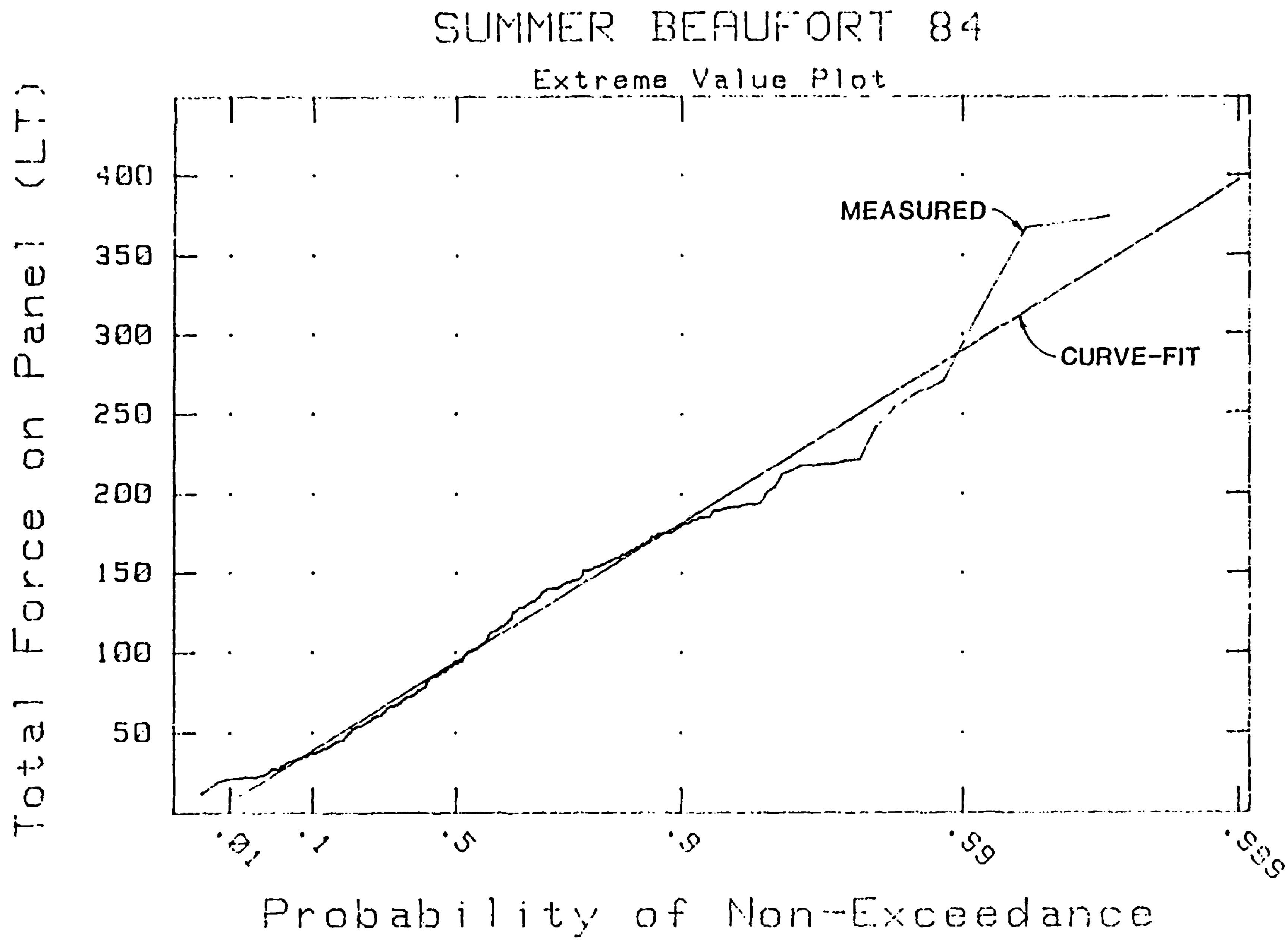

ANTARCTIC SUMMER 84
Extreme Value Plot
MEASURED
CURVE-FIT
Total Force on Panel (LT)
300
250
200
150
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

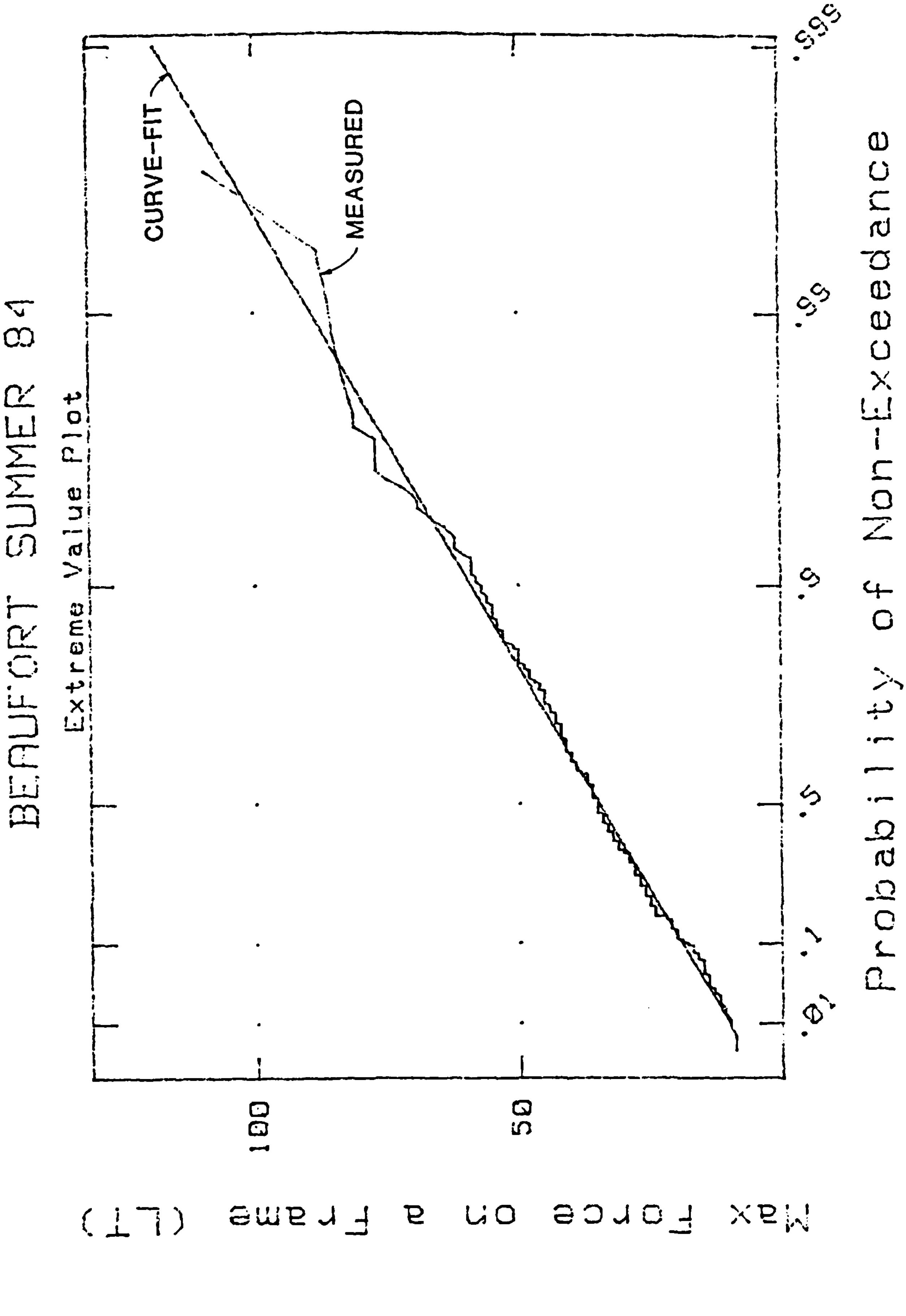

ANTARCTIC SUMMER 84
Extreme Value Plot
CURVE-FIT
MEASURED
90
80
70
60
50
40
30
20
10
Max Force on a Frame (LT)
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

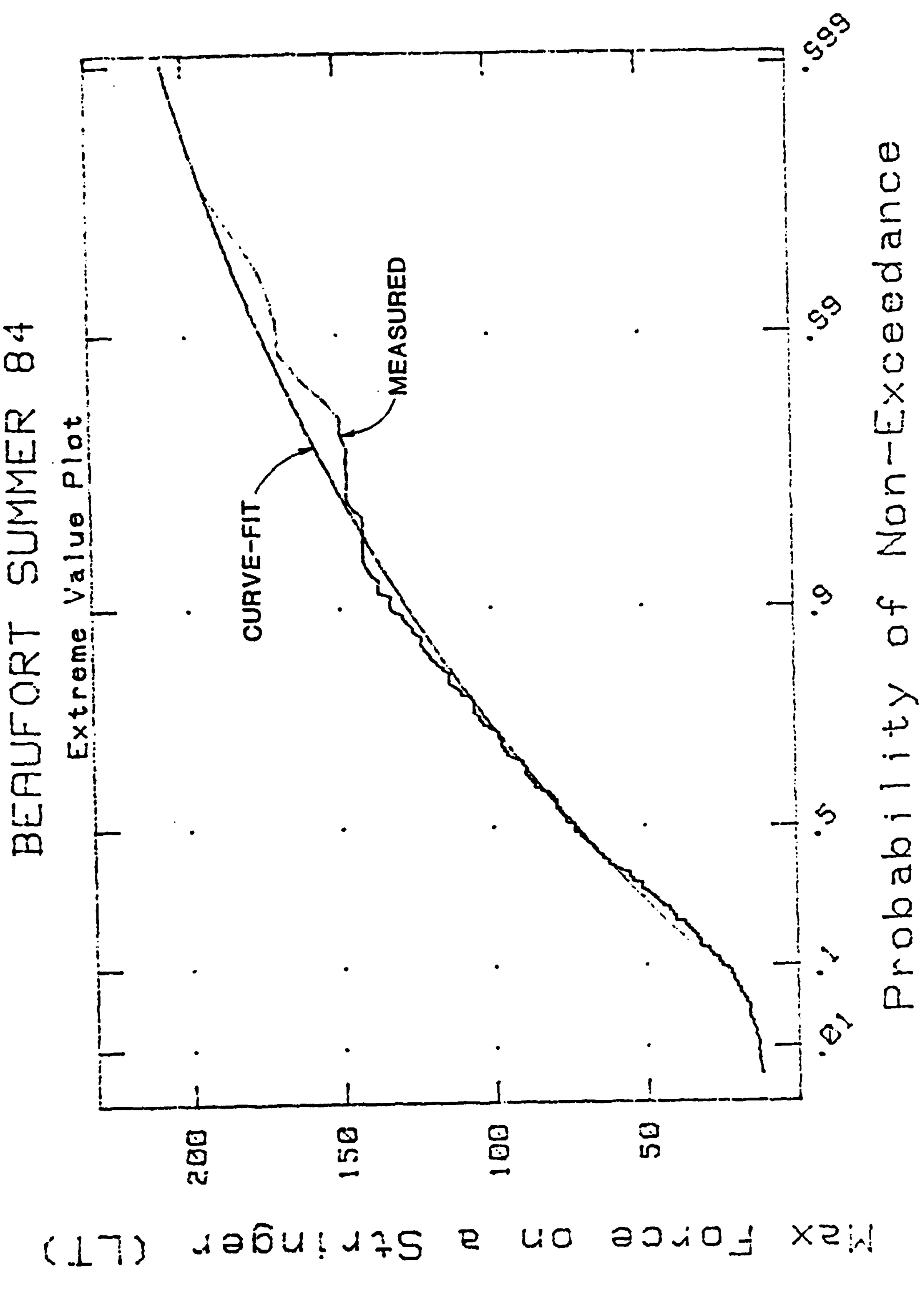

ANTARCTIC SUMMER 84
Extreme Value Plot
CURVE-FIT
MEASURED
200
150
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max Force on a Stringer (LT)


BEAUFORT SUMMER 84
Extreme Value Plot
MEASURED
CURVE-FIT
1000
500
Max 1 Sub-panel Pres (psi)
.02
.1
.5
.9
.99
.999
Probability of Non-Exceedance

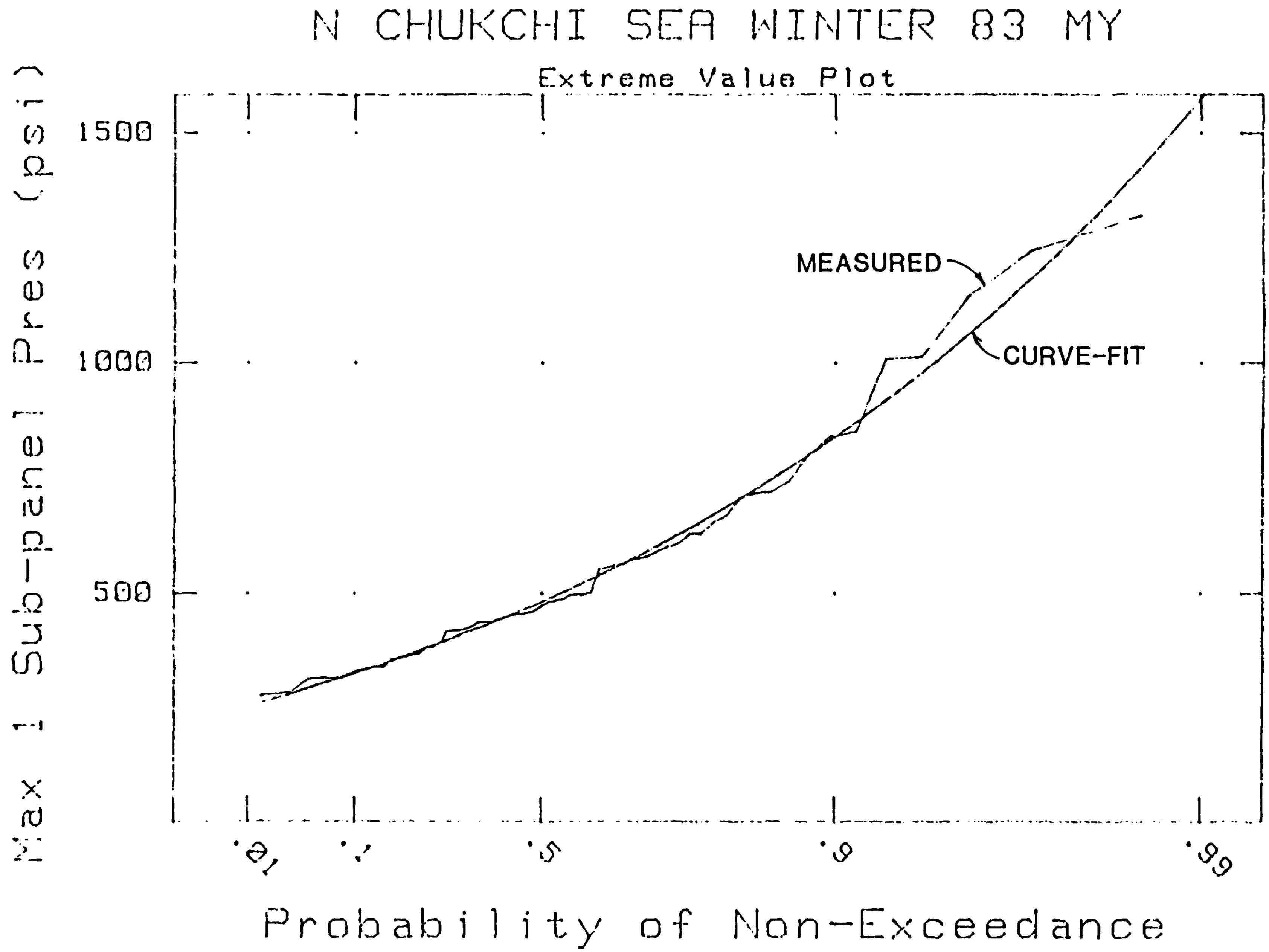

BEAUFORT SUMMER 84
Extreme Value Plot
MEASURED
CURVE-FIT
500
400
300
200
100
.01
.1
.5
.9
.99
.999
Max 4 Sub-panel Pres (psi)
Probability of Non-Exceedance

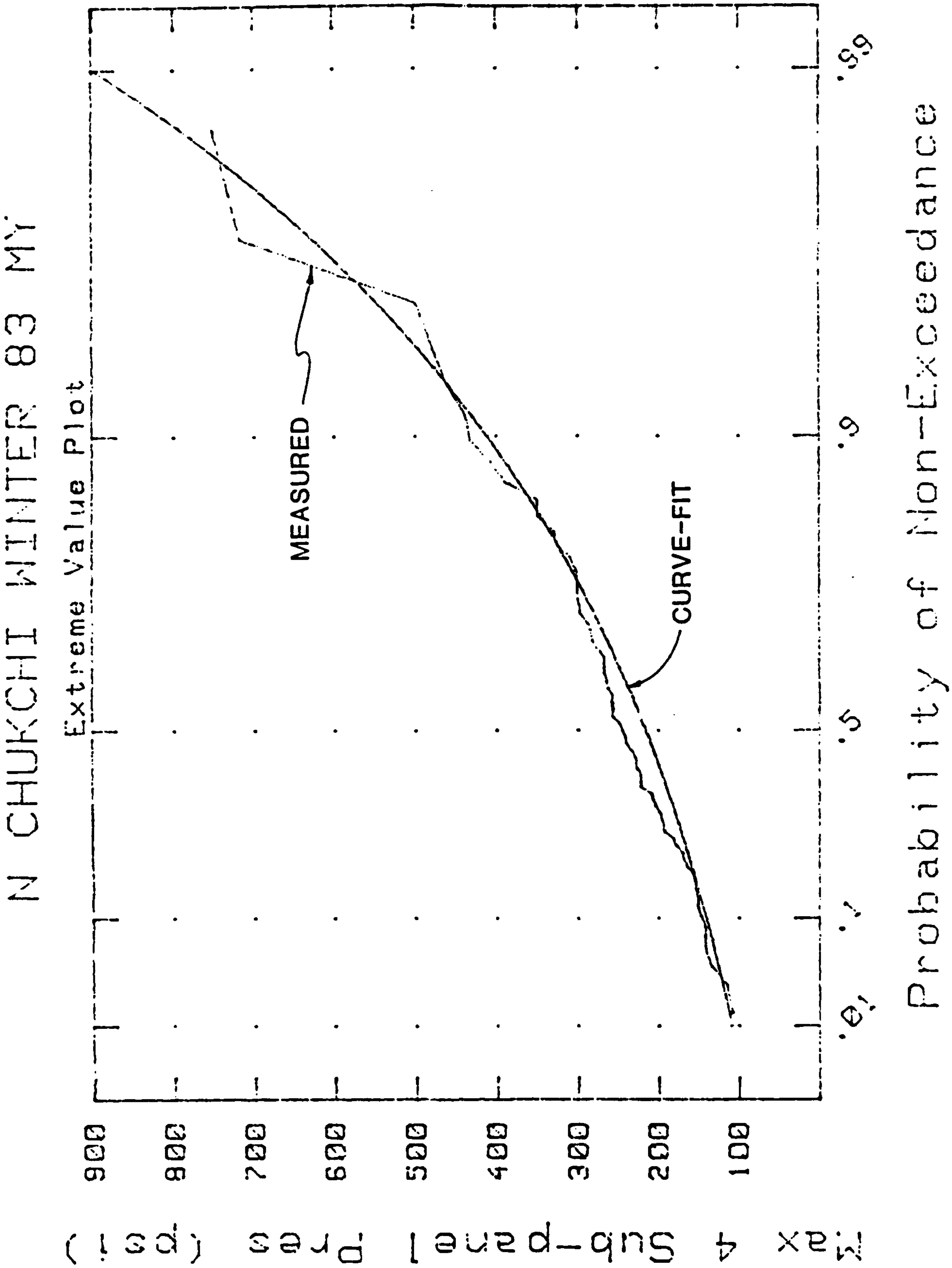

SUMMER BEAUFORT 84
Extreme Value Plot
Total Force on Panel (LT)
400
350
300
250
200
150
100
50
MEASURED
CURVE-FIT
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance


BEAUFORT SUMMER 84
Extreme Value Plot
CURVE-FIT
MEASURED
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance
Max Force on a Frame (LT)

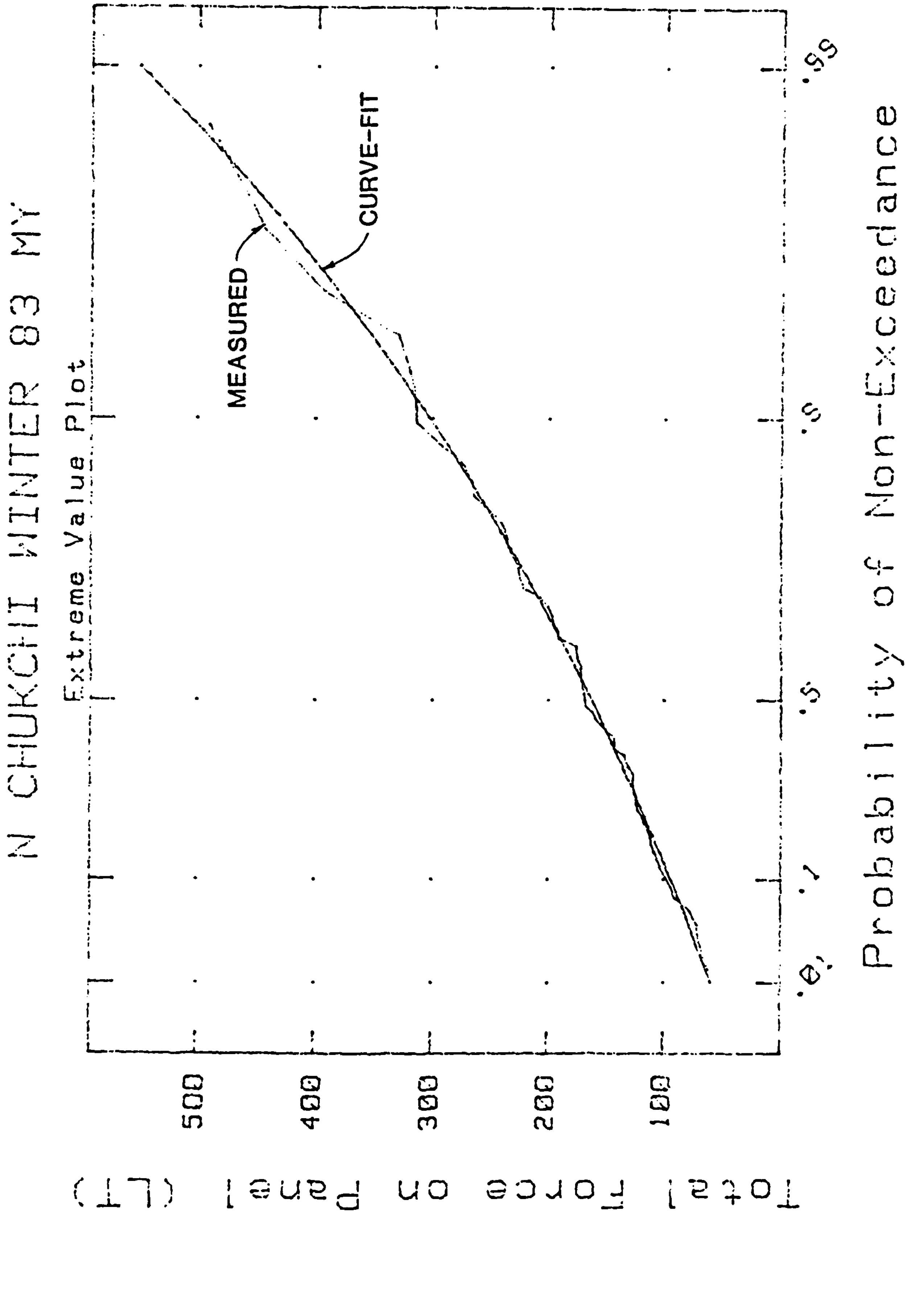


BEAUFORT SUMMER 84
Extreme Value Plot
CURVE-FIT
MEASURED
Probability of Non-Exceedance
.01
.1
.5
.9
.99
.999
Max Force on a Stringer (LT)
200
150
100
50

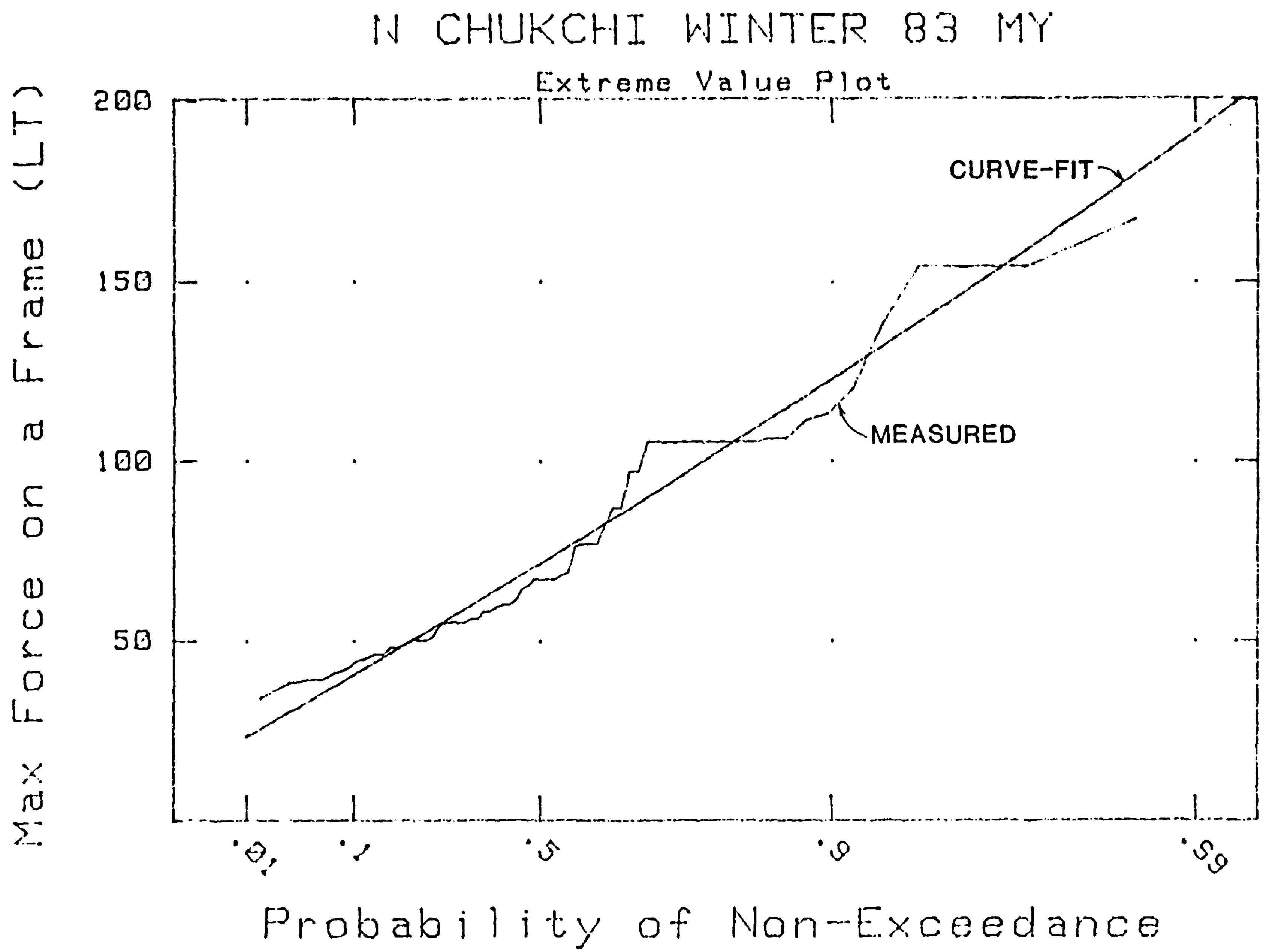

N CHUKCHI SEA WINTER 83 MY
Extreme Value Plot
Max 1 Sub-panel Pres (psi)
1500
1000
500
MEASURED
CURVE-FIT
.01
.1
.5
.9
.99
Probability of Non-Exceedance

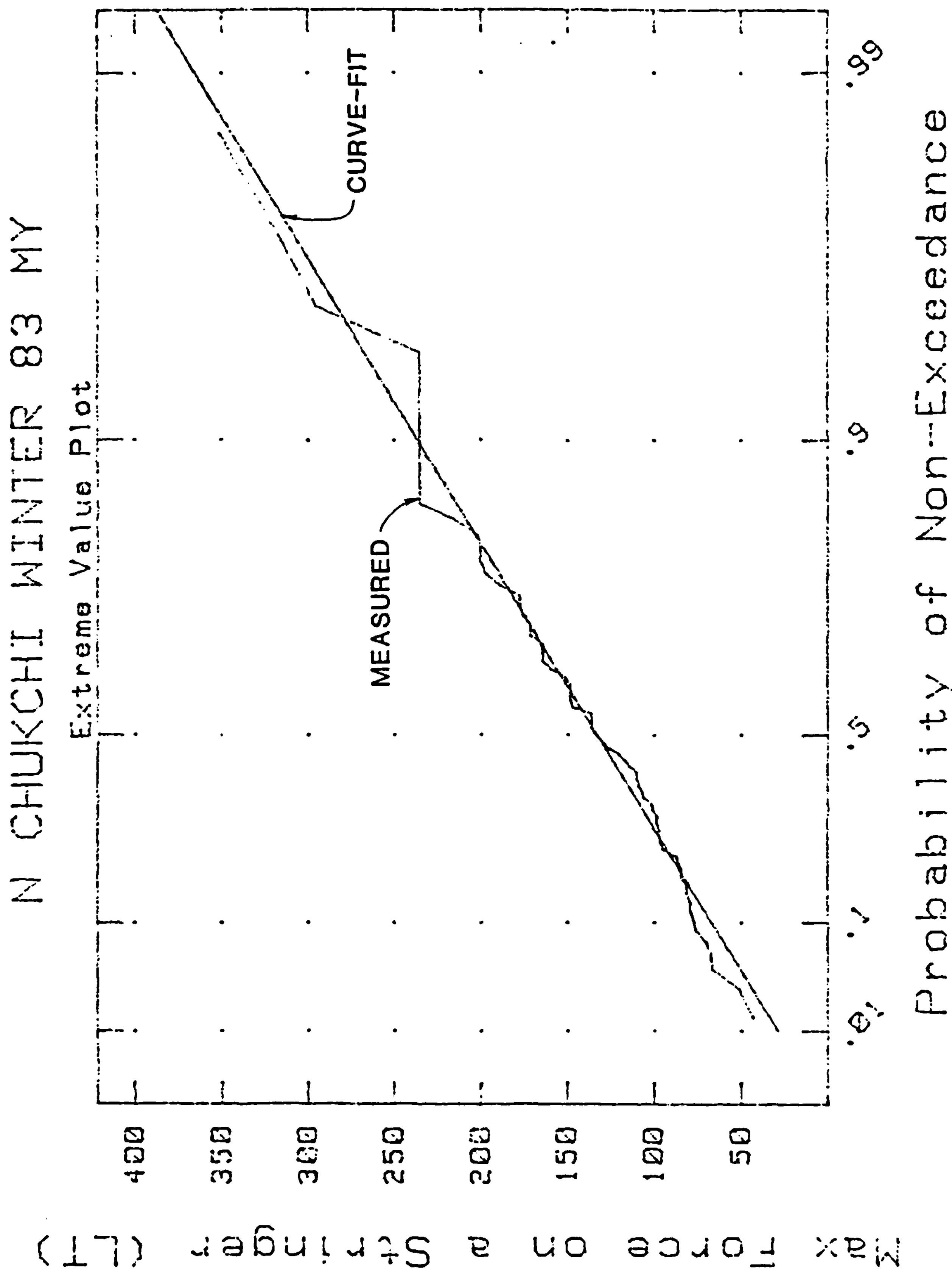


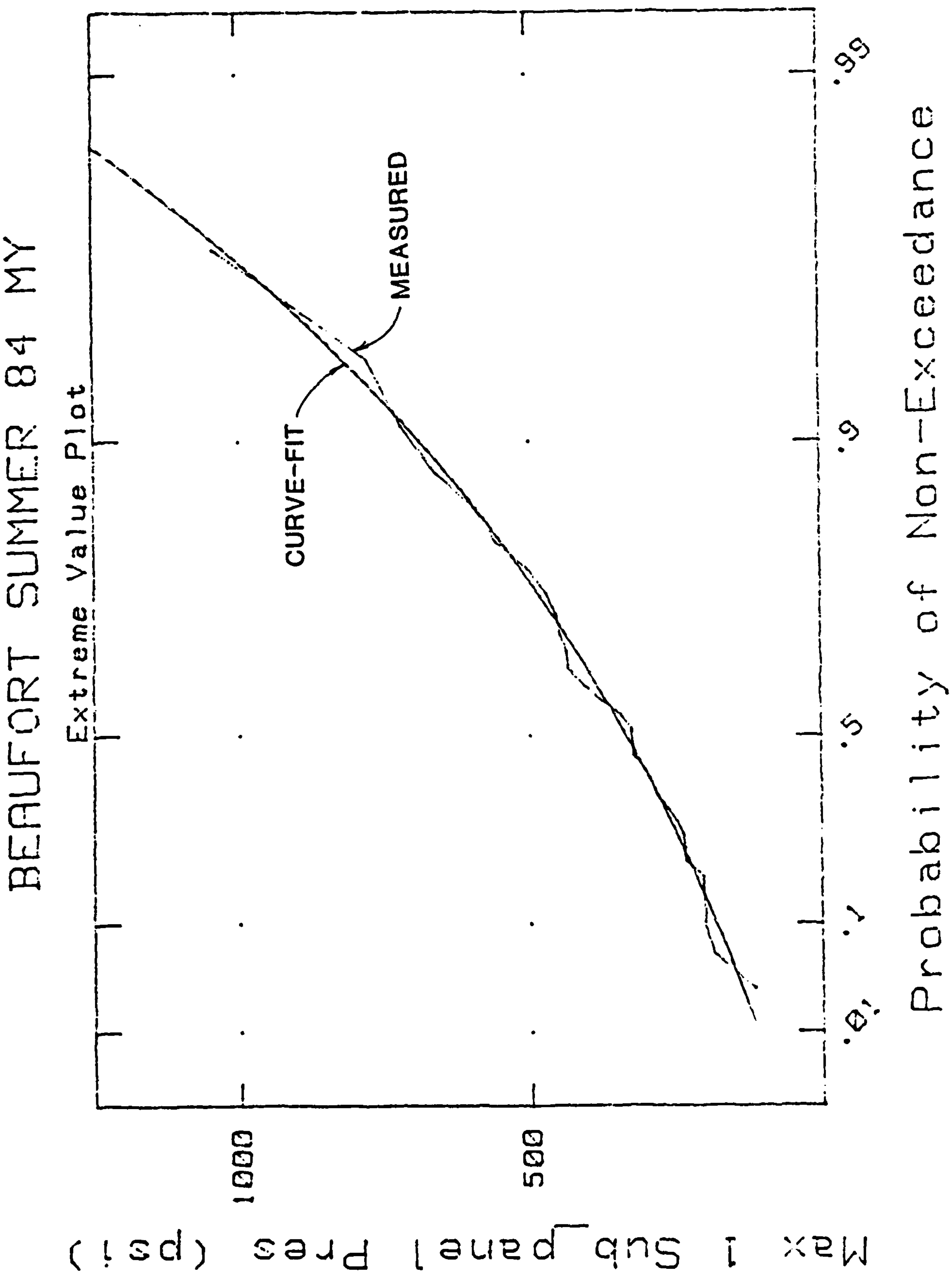
N CHUKCHI WINTER 83 MY
Extreme Value Plot
Max 4 Sub-panel Pres (psi)
900
800
700
600
500
400
300
200
100
Probability of Non-Exceedance
.01
.1
.5
.9
.99
MEASURED
CURVE-FIT



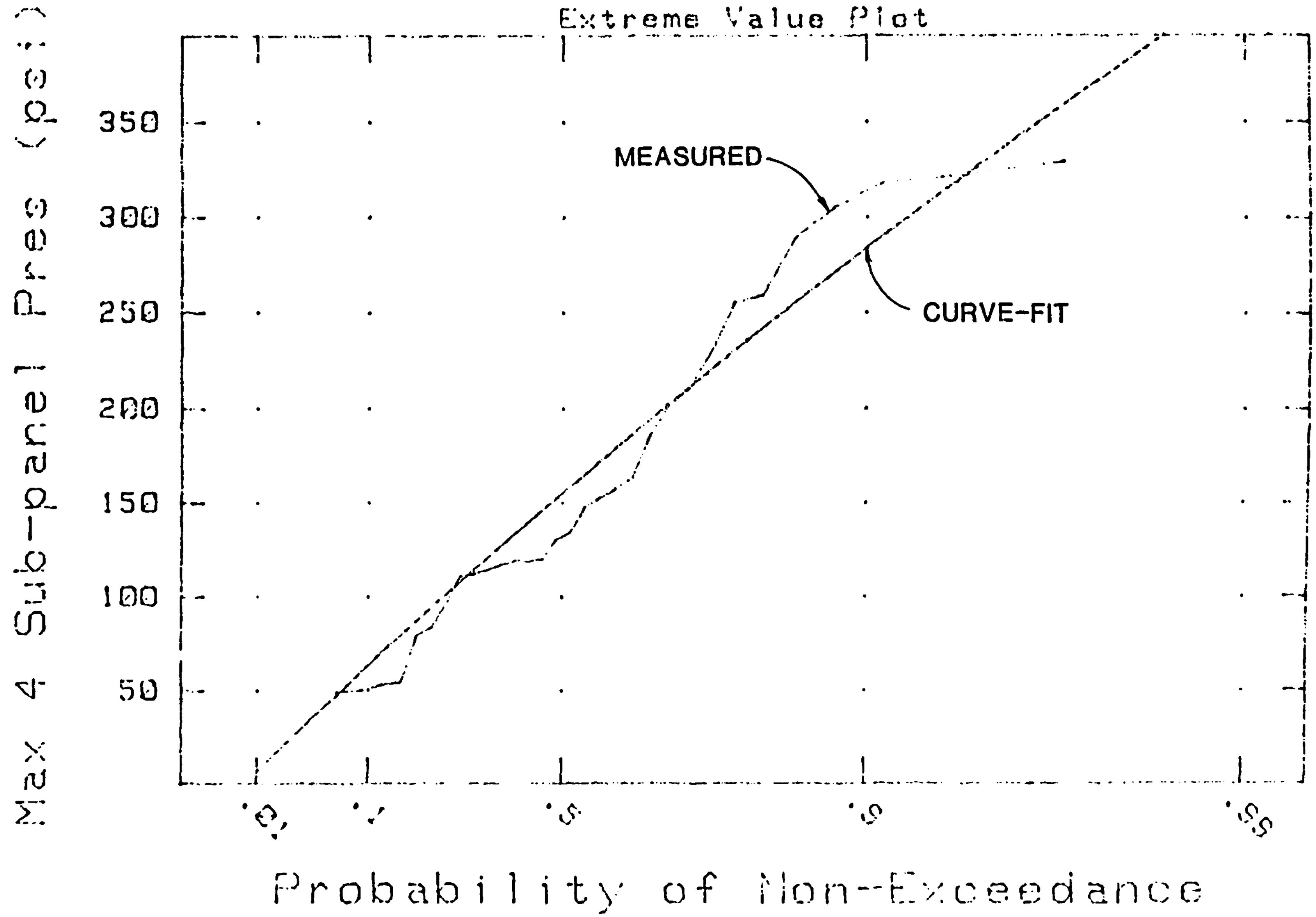
N CHUKCHI WINTER 83 MY
Extreme Value Plot
MEASURED
CURVE-FIT
500
400
300
200
100
Total Force on Panel (LT)
.01
.1
.5
.9
.99
Probability of Non-Exceedance

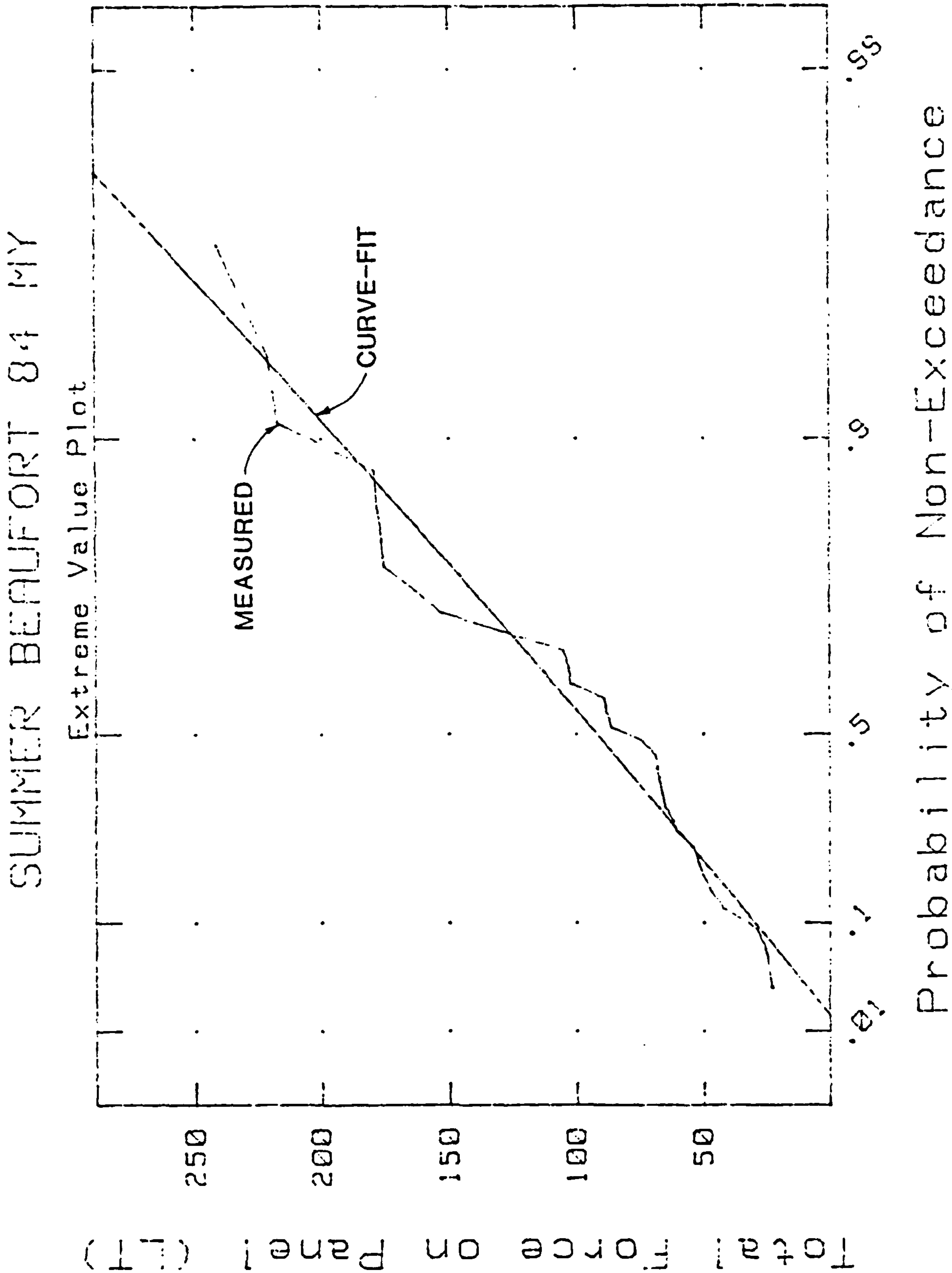

N CHUKCHI WINTER 83 MY
Extreme Value Plot
Max Force on a Frame (LT)
200
150
100
50
CURVE-FIT
MEASURED
Probability of Non-Exceedance

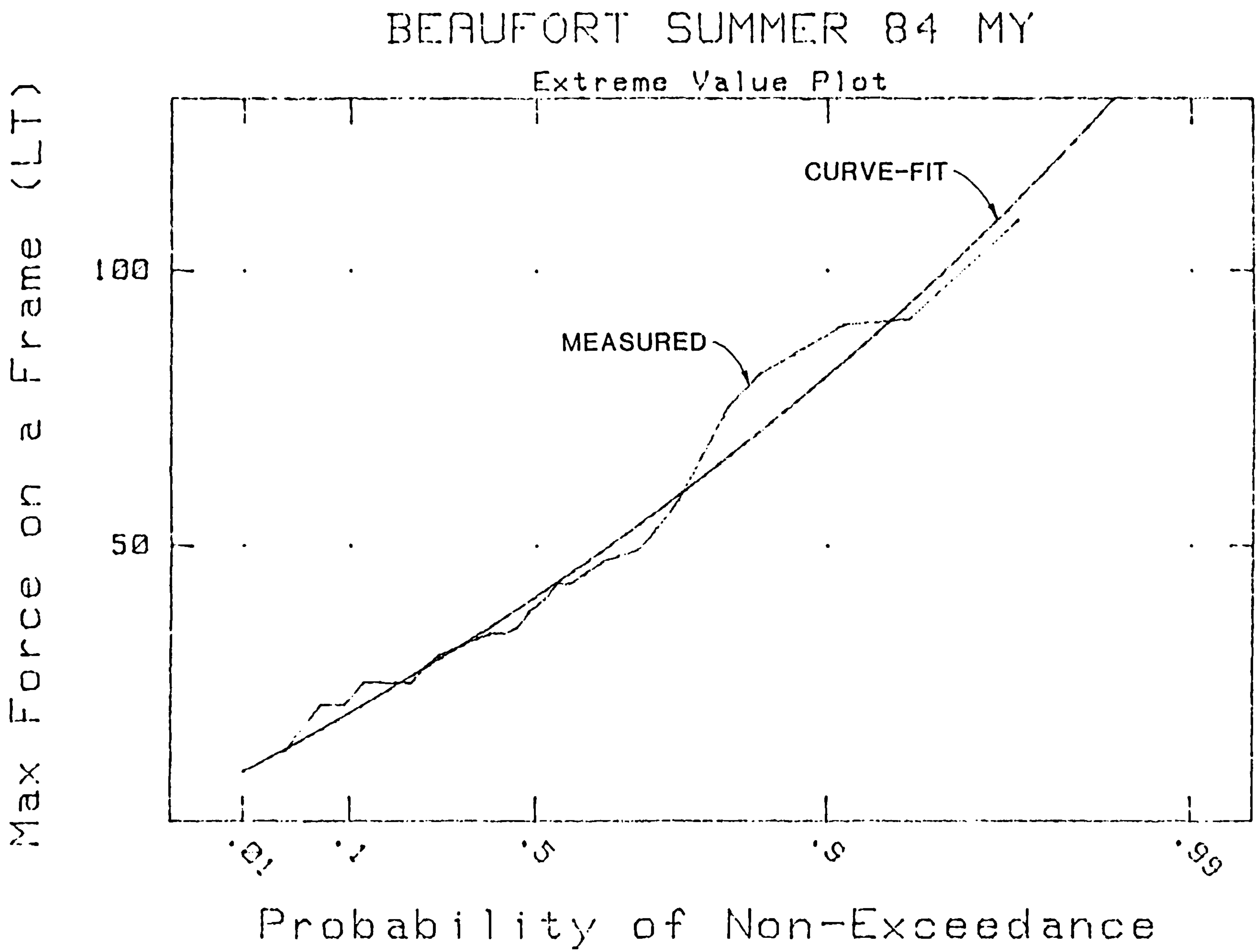

N CHUKCHI WINTER 83 MY
Extreme Value Plot
CURVE-FIT
MEASURED
Max Force on a Stringer (LT)
400
350
300
250
200
150
100
50
Probability of Non-Exceedance
.01
.1
.5
.9
.99

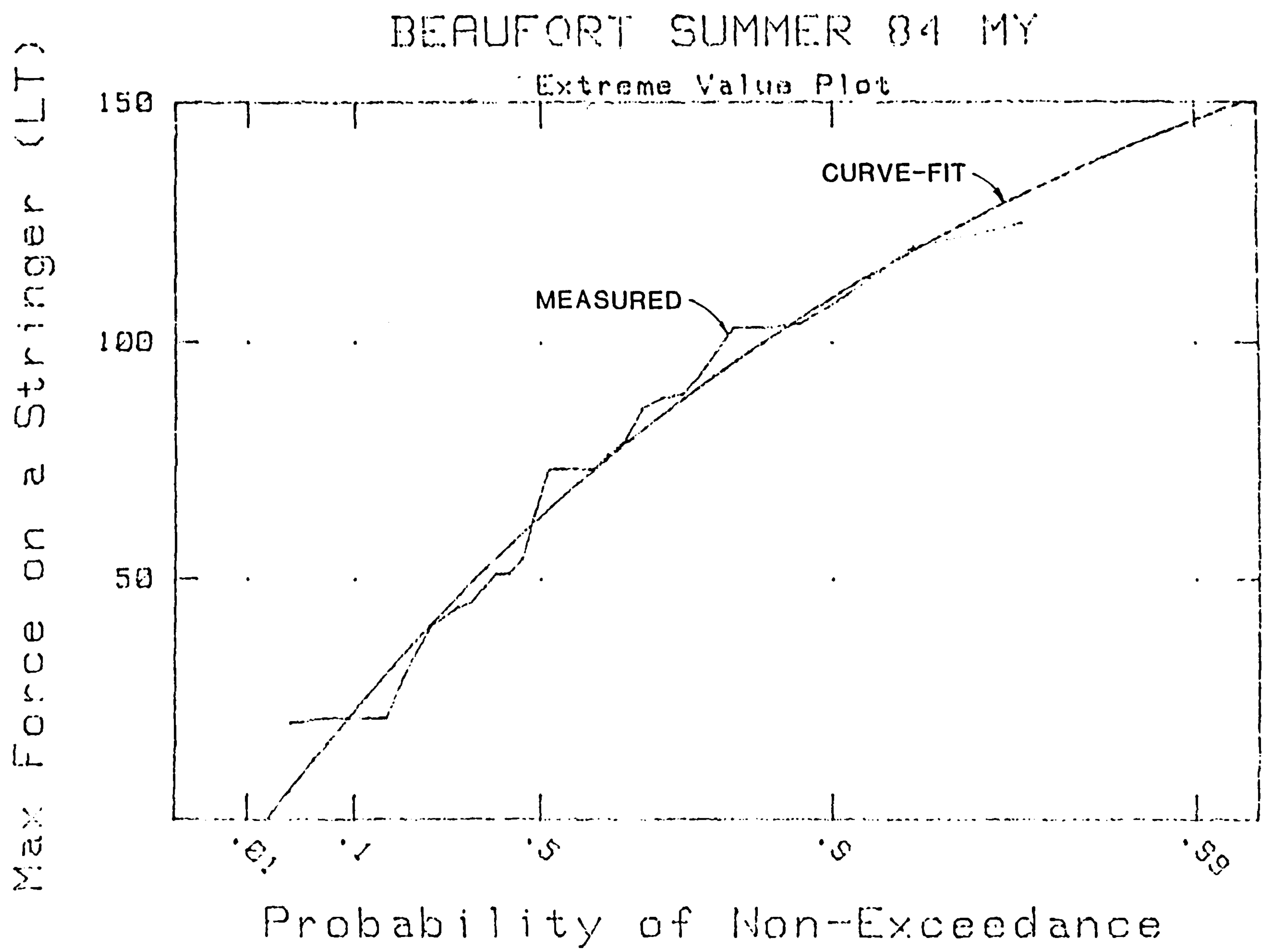

BEAUFORT SUMMER 84 MY
Extreme Value Plot
MEASURED
CURVE-FIT
1000
500
.01
.1
.5
.9
.99
Probability of Non-Exceedance
Max 1 Sub_panel Pres (psi)

BEAUFORT SUMMER 84 MY

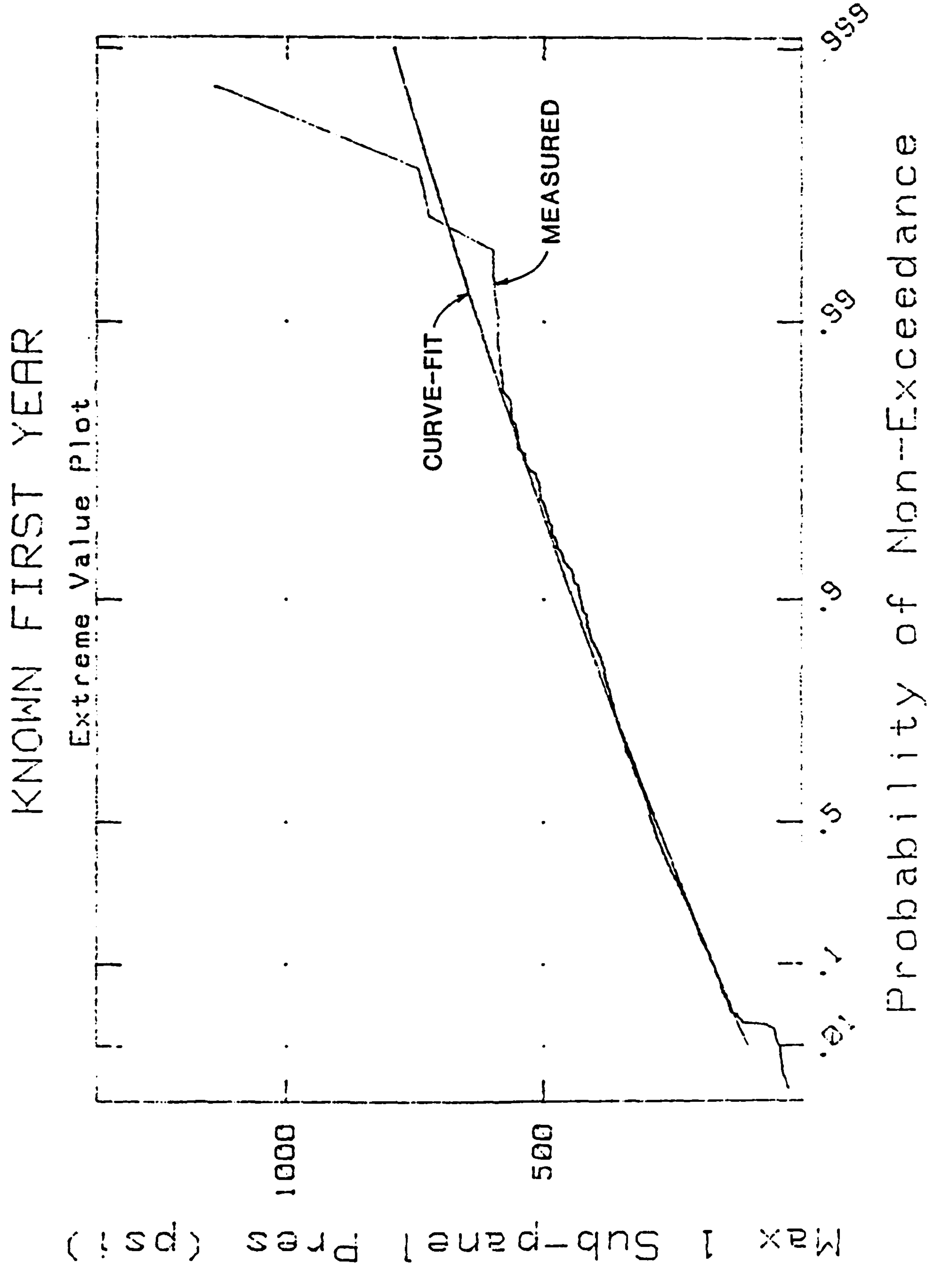



SUMMER BEAUFORT 84 MY
Extreme Value Plot
CURVE-FIT
MEASURED
250
200
150
100
50
.01
.1
.5
.9
.99
Probability of Non-Exceedance
Total Force on Panel (LT)

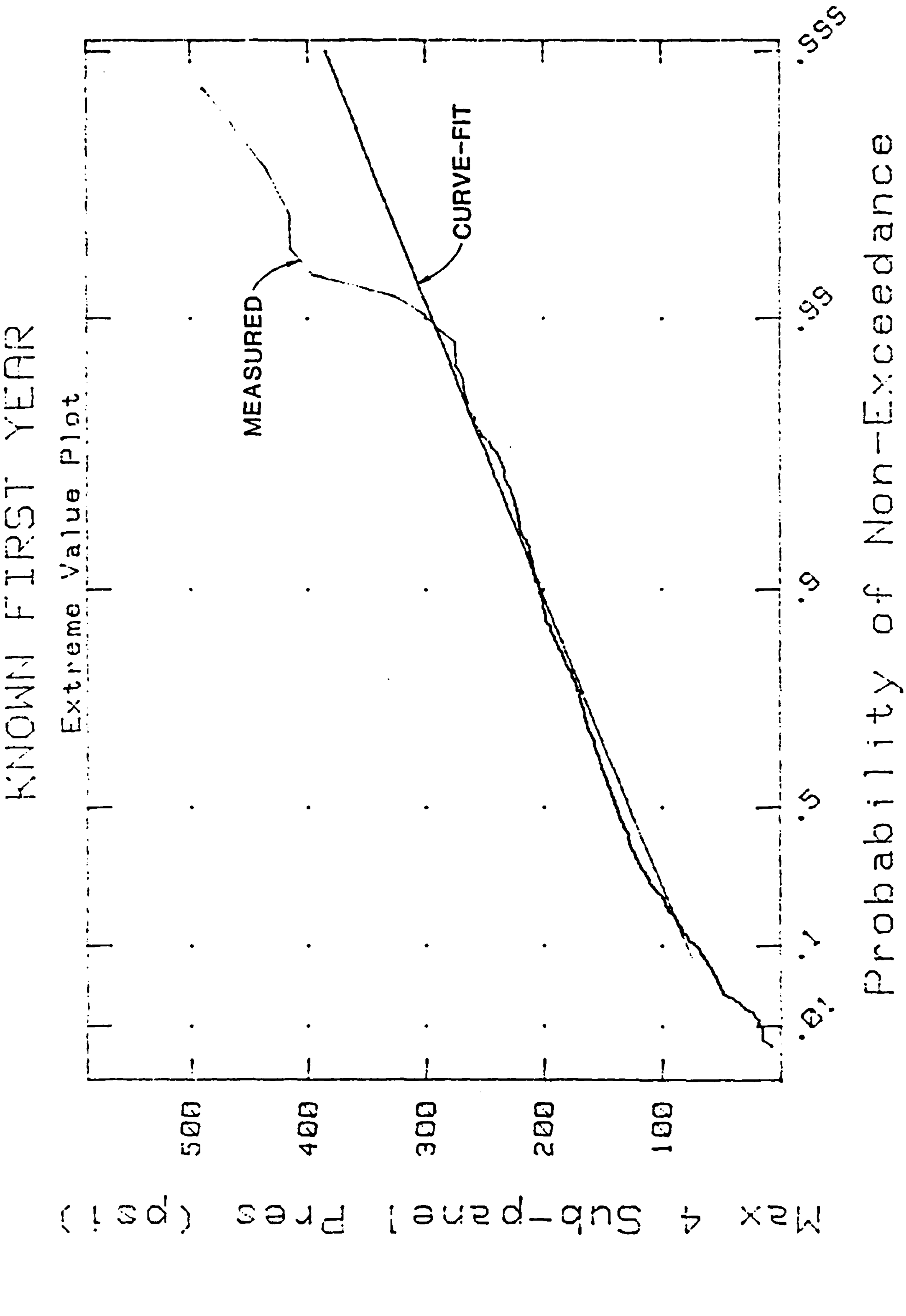

BEAUFORT SUMMER 84 MY
Extreme Value Plot
CURVE-FIT
MEASURED
100
50
Max Force on a Frame (LT)
.01
.1
.5
.9
.99
Probability of Non-Exceedance

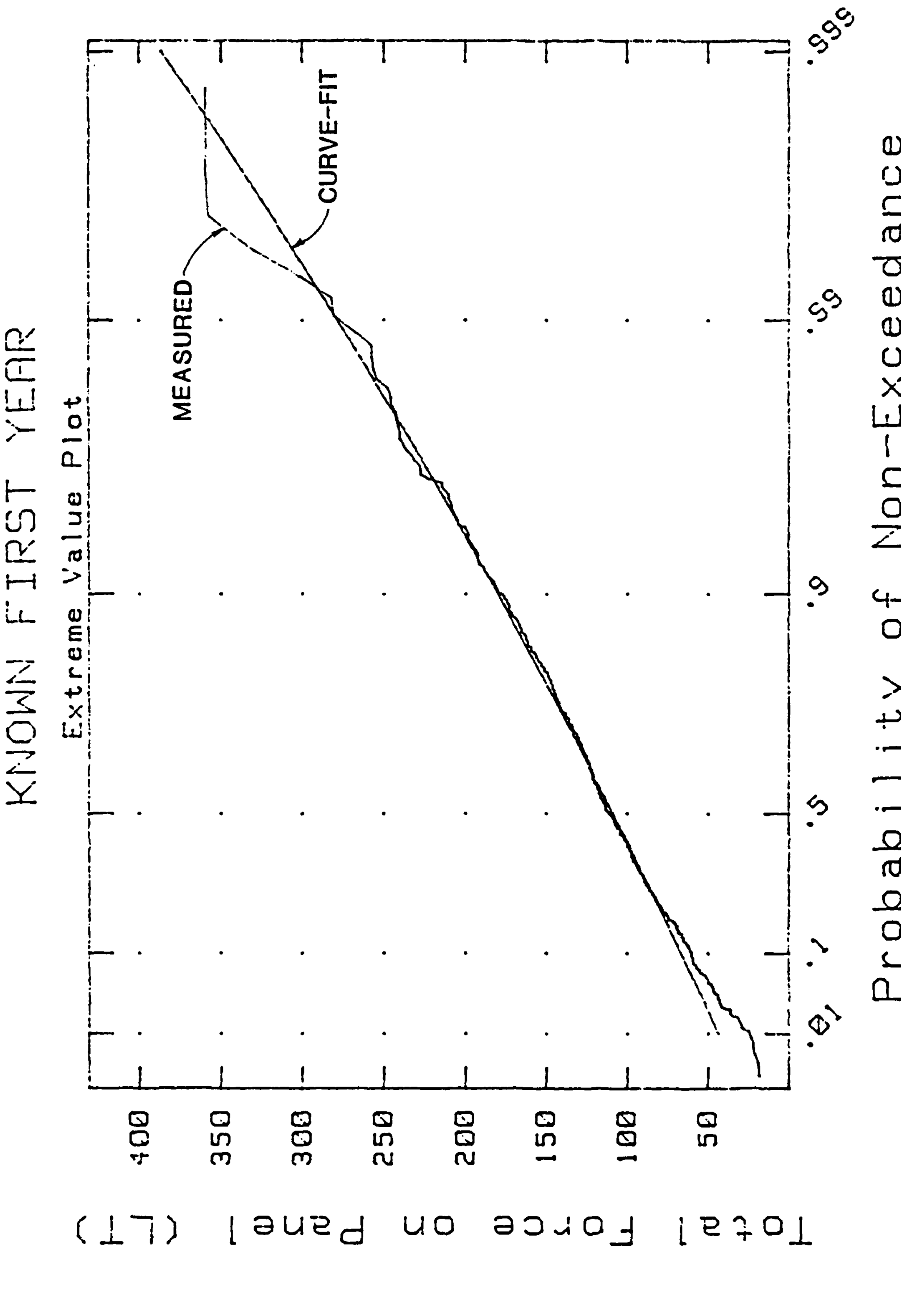


BEAUFORT SUMMER 84 MY
Extreme Value Plot
150
100
50
CURVE-FIT
MEASURED
Max Force on a Stringer (LT)
Probability of Non-Exceedance

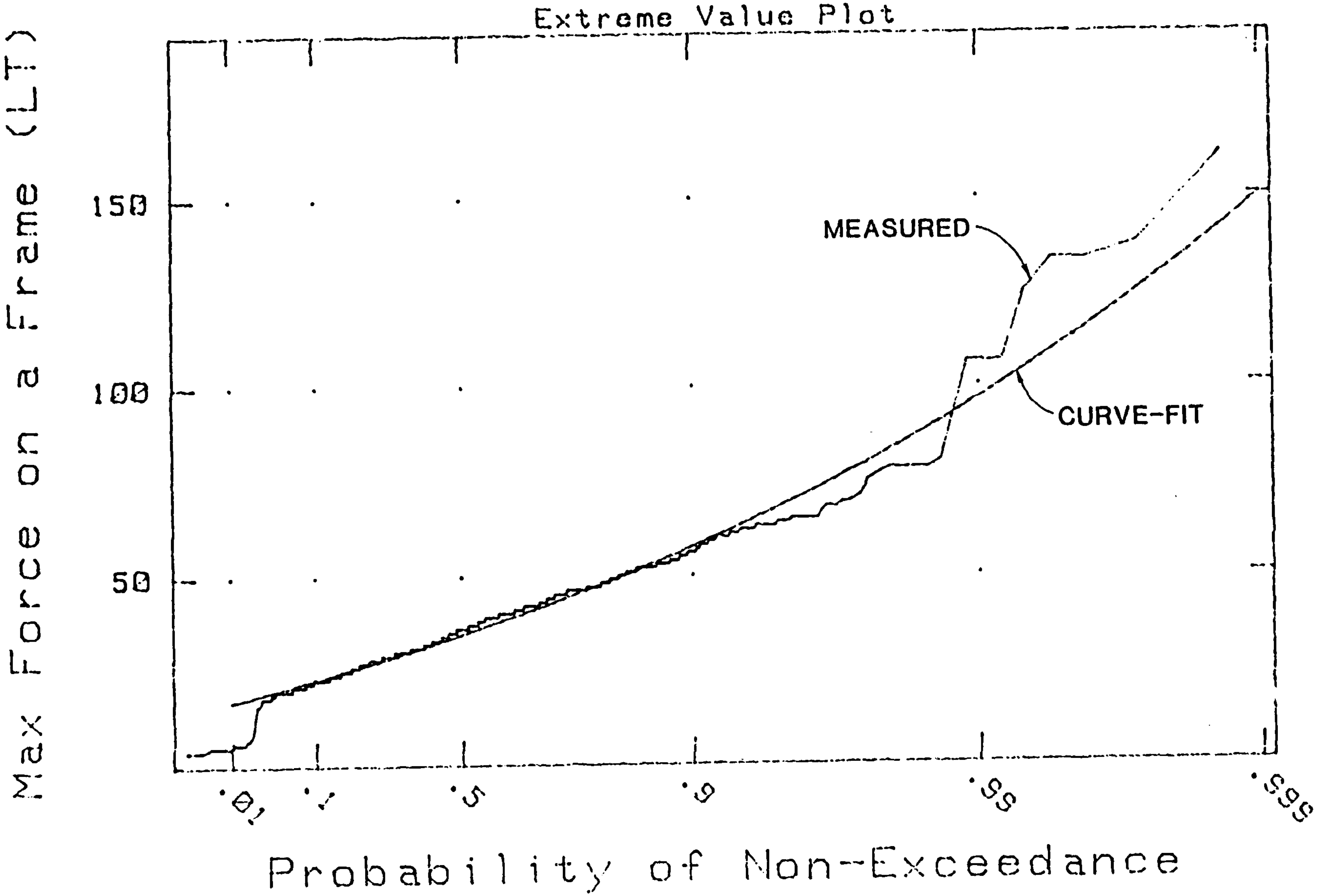


KNOWN FIRST YEAR
Extreme Value Plot
MEASURED
CURVE-FIT
1000
500
Max 1 Sub-panel Pres (psi)
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance


KNOWN FIRST YEAR
Extreme Value Plot
MEASURED
CURVE-FIT
Max 4 Sub-panel Pres (psi)
Probability of Non-Exceedance
500
400
300
200
100
.01
.1
.5
.9
.99
.999

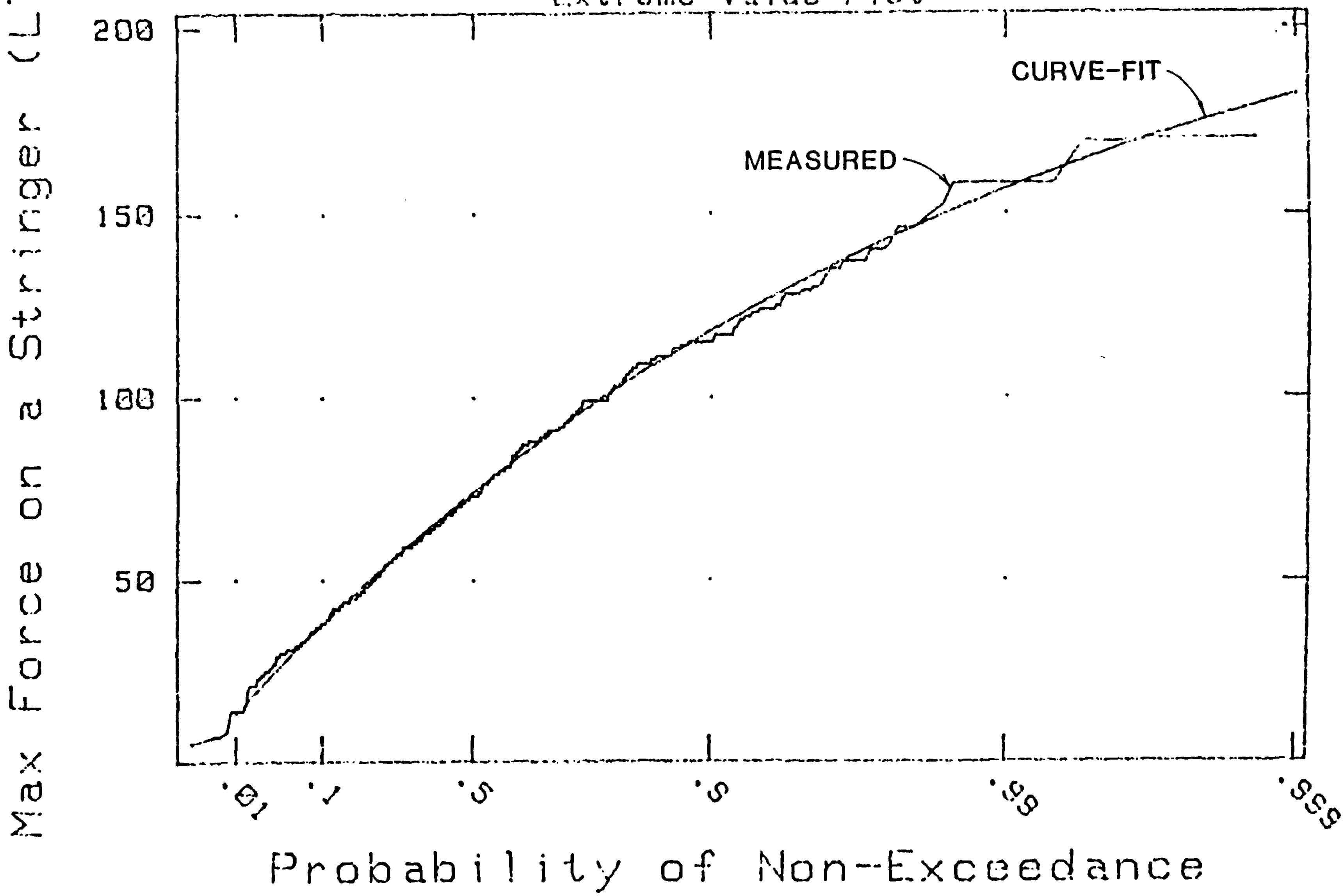

KNOWN FIRST YEAR
Extreme Value Plot
MEASURED
CURVE-FIT
Total Force on Panel (LT)
400
350
300
250
200
150
100
50
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

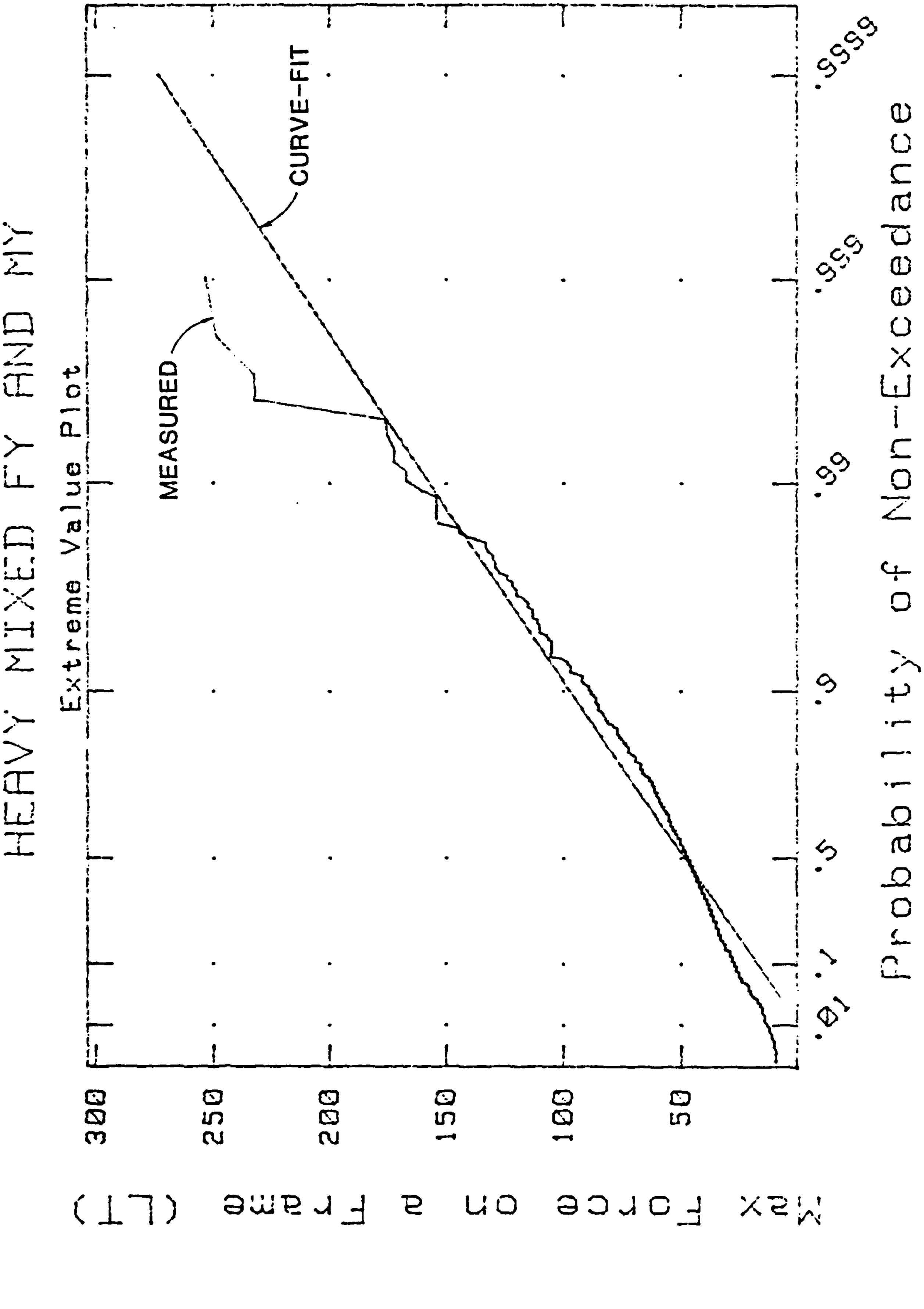
KNOWN FIRST YEAR

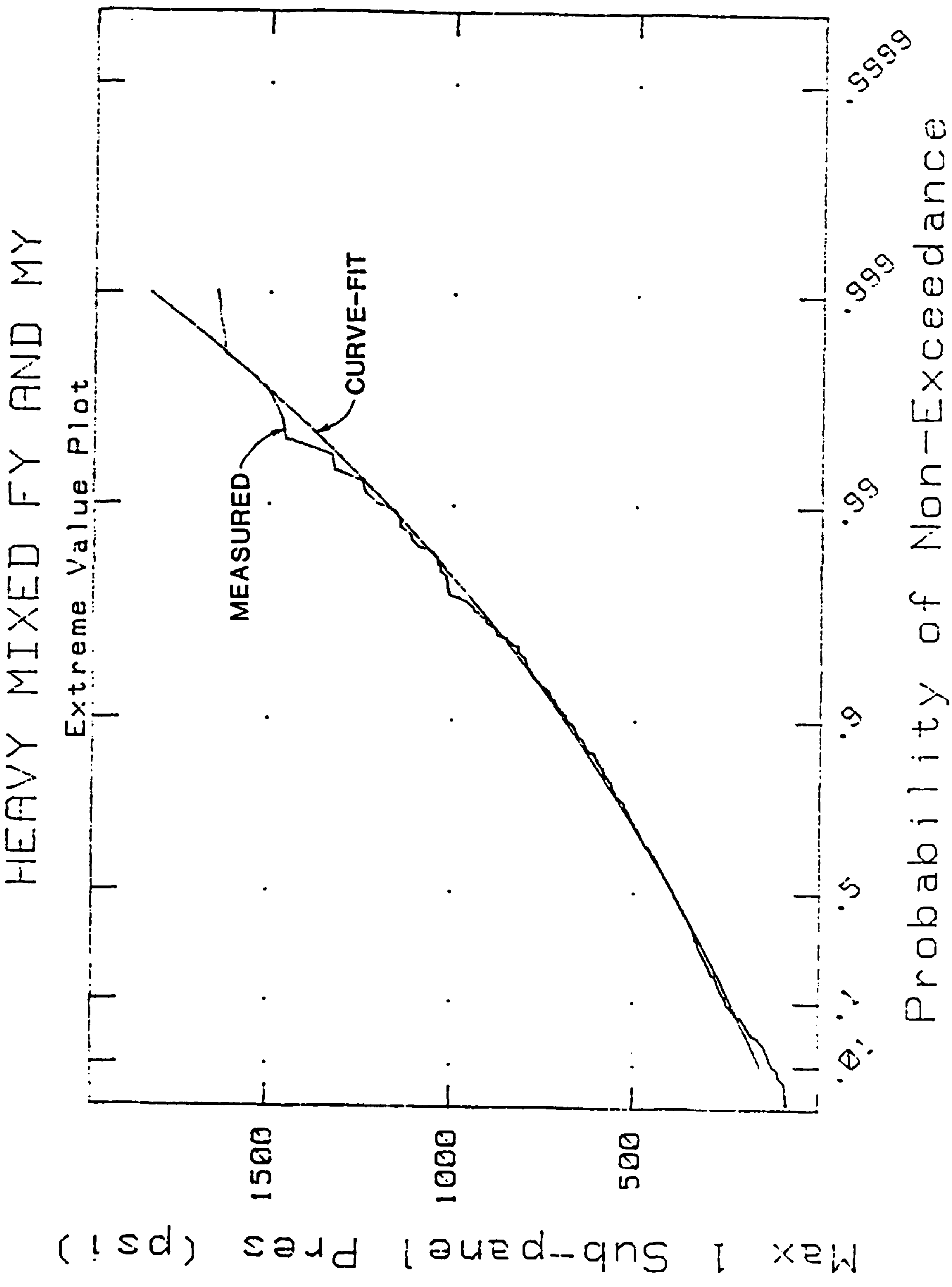


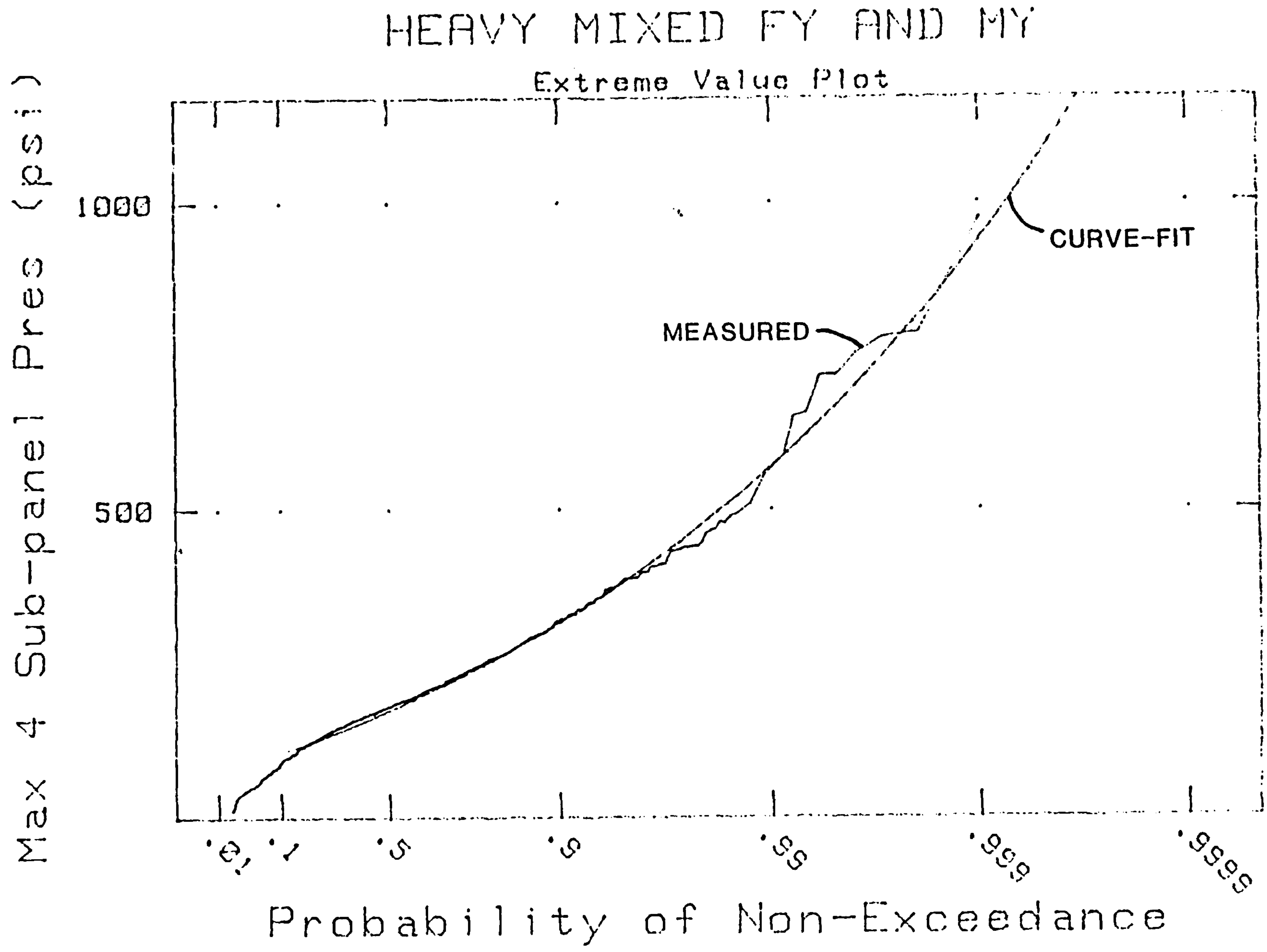
KNOWN FIRST YEAR

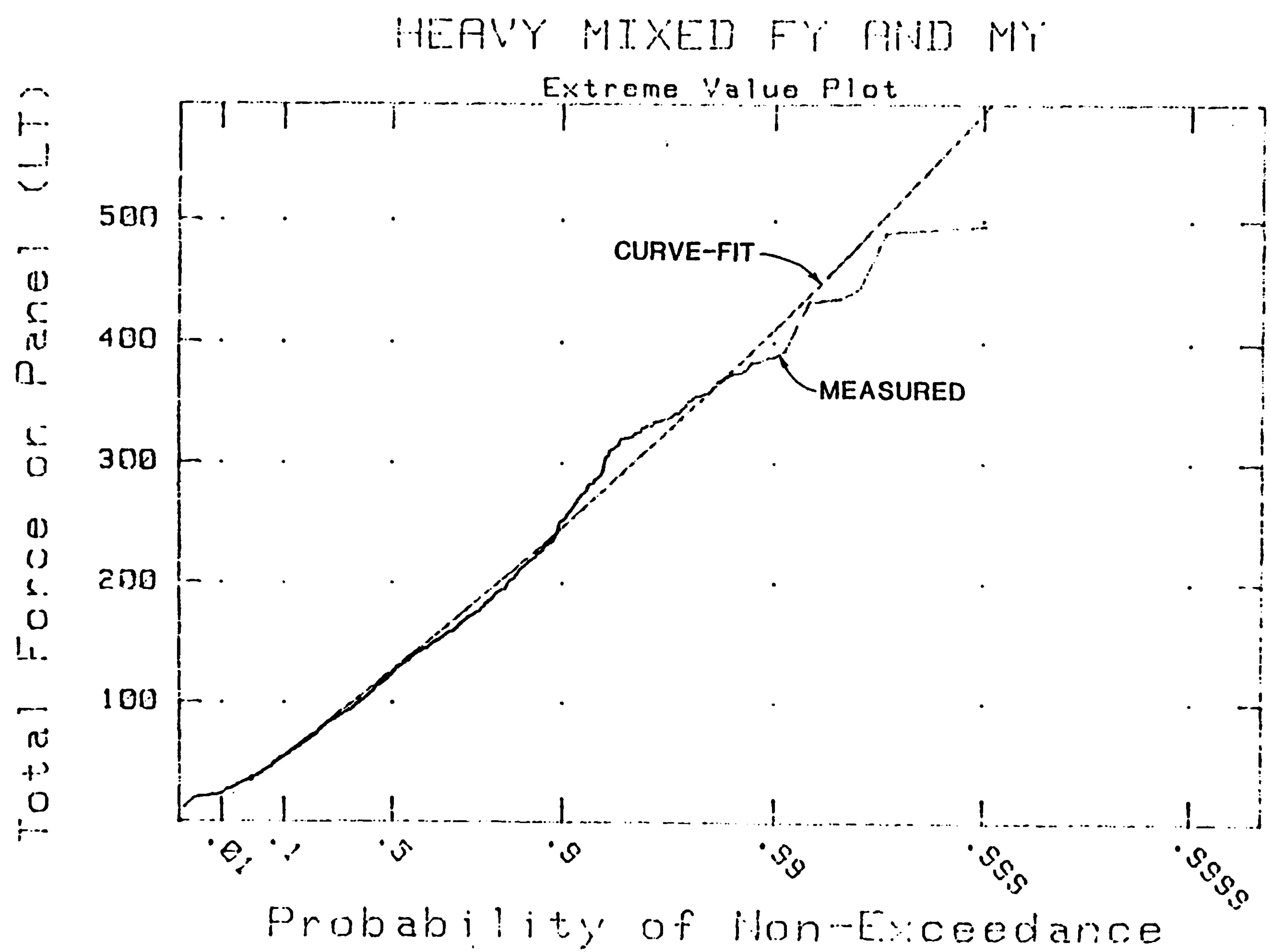
Extreme Value Plot



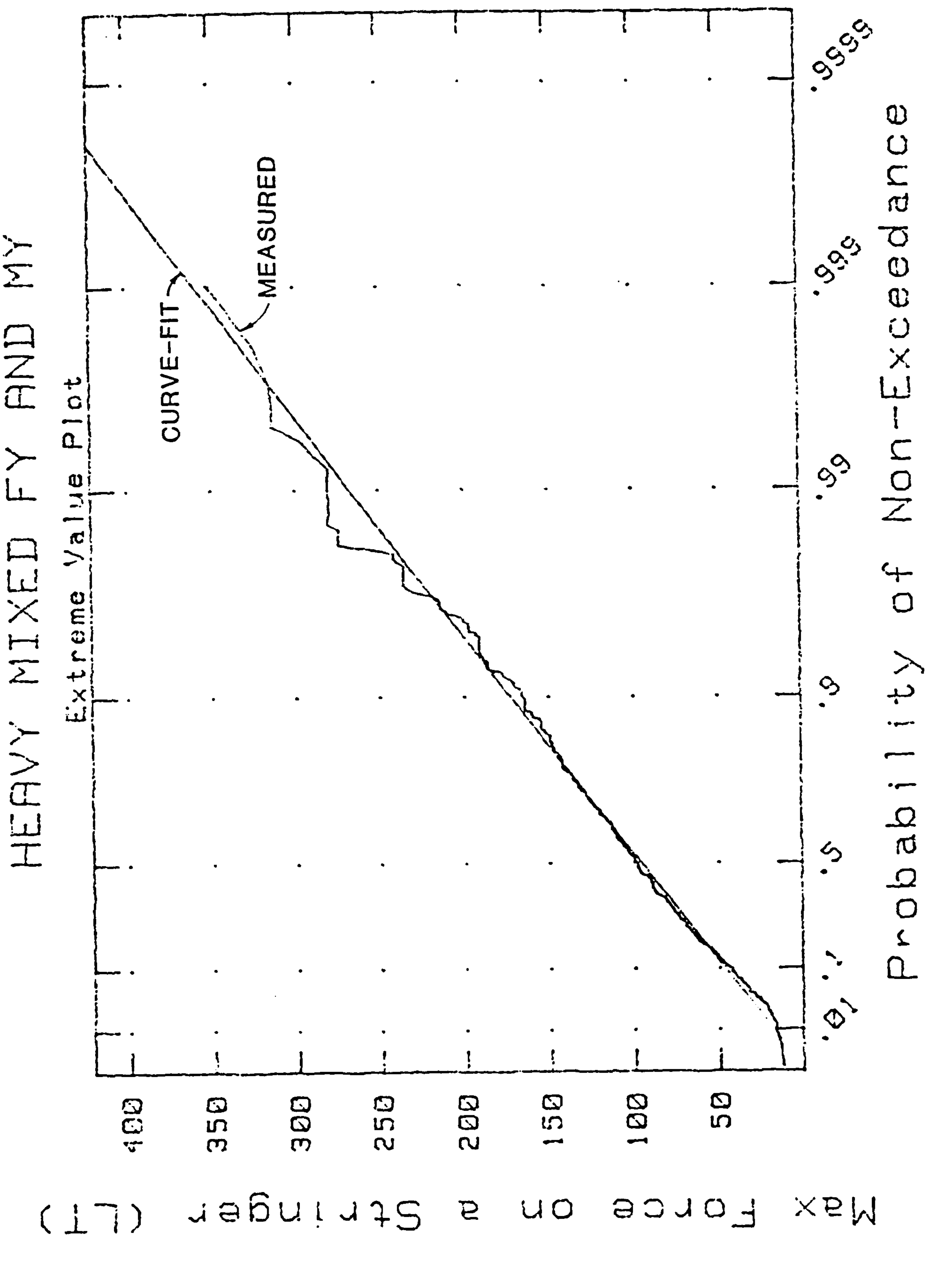

HEAVY MIXED FY AND MY
Extreme Value Plot
CURVE-FIT
MEASURED
Max Force on a Frame (LT)
300
250
200
150
100
50
Probability of Non-Exceedance
.01
.1
.5
.9
.99
.999
.9999


HEAVY MIXED FY AND MY
Extreme Value Plot
MEASURED
CURVE-FIT
Probability of Non-Exceedance
.5
.9
.99
.999
.9999
1500
1000
500
Max 1 Sub-panel Pres (psi)


HEAVY MIXED FY AND MY
Extreme Value Plot
1000
500
Max 4 Sub-panel Pres (psi)
CURVE-FIT
MEASURED
.01
.1
.5
.9
.99
.999
.9999
Probability of Non-Exceedance



HEAVY MIXED FY AND MY
Extreme Value Plot
CURVE-FIT
MEASURED
500
400
300
200
100
Total Force on Panel (LT)
.01
.1
.5
.9
.99
.999
.9999
Probability of Non-Exceedance


HEAVY MIXED FY AND MY
Extreme Value Plot
CURVE-FIT
MEASURED
Max Force on a Stringer (LT)
400
350
300
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200
150
100
50
Probability of Non-Exceedance
.01
.1
.5
.9
.99
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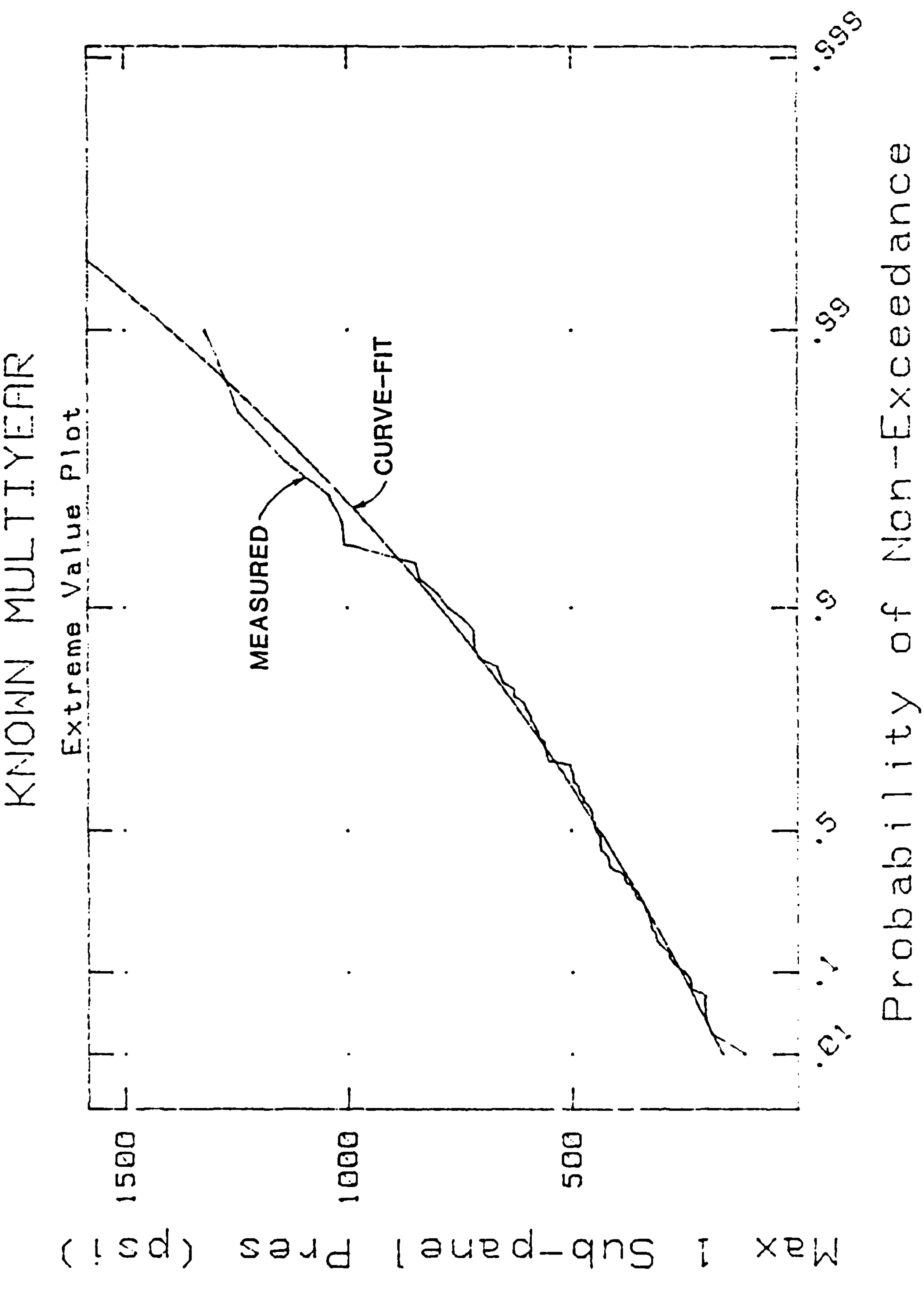
KNOWN MULTIYEAR
Extreme Value Plot
MEASURED
CURVE-FIT
Max 1 Sub-panel Pres (psi)
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Probability of Non-Exceedance
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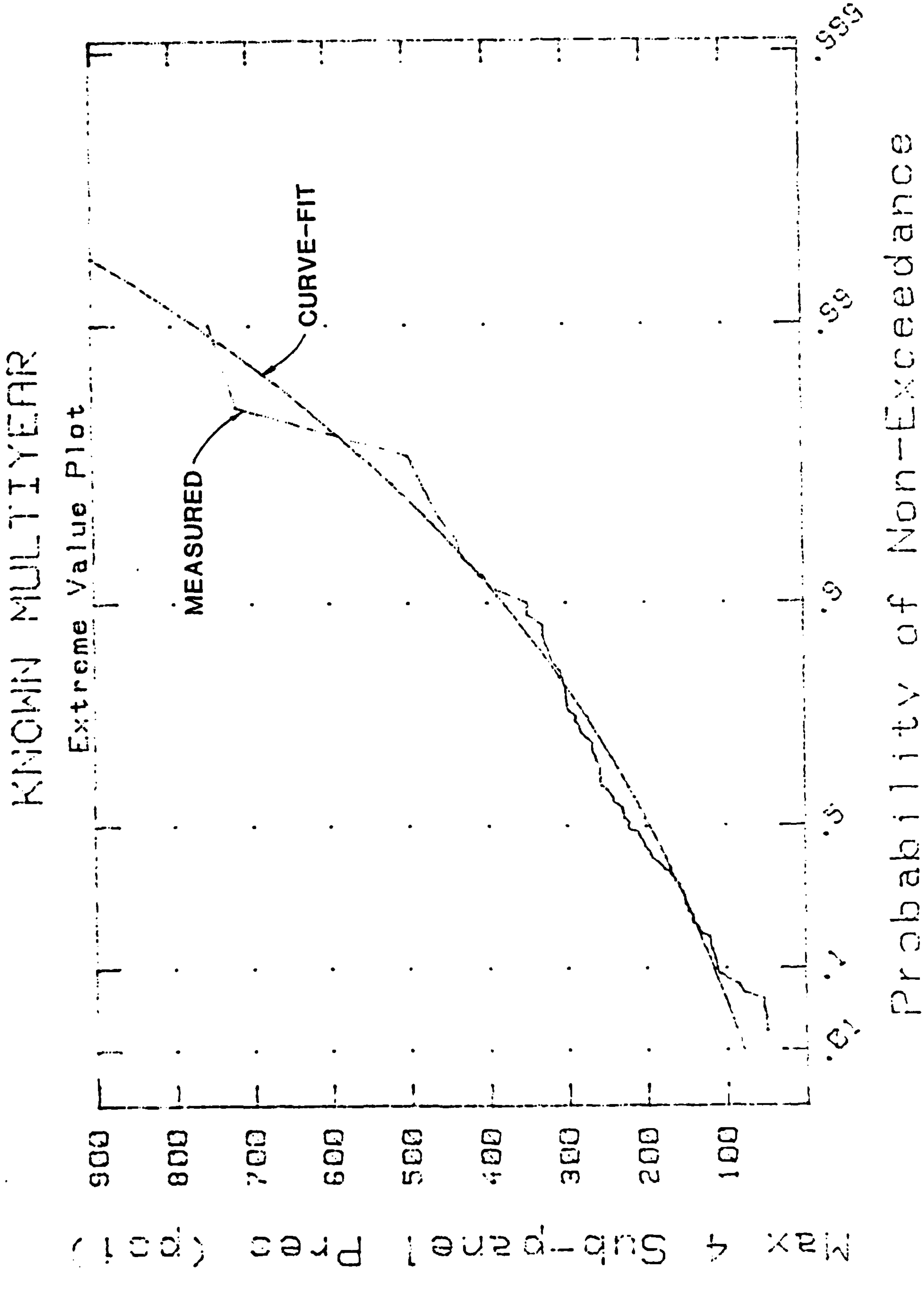
KNOWN MULTIYEAR
Extreme Value Plot
CURVE-FIT
MEASURED
Max 4 Sub-panel Pres (psi)
Probability of Non-Exceedance
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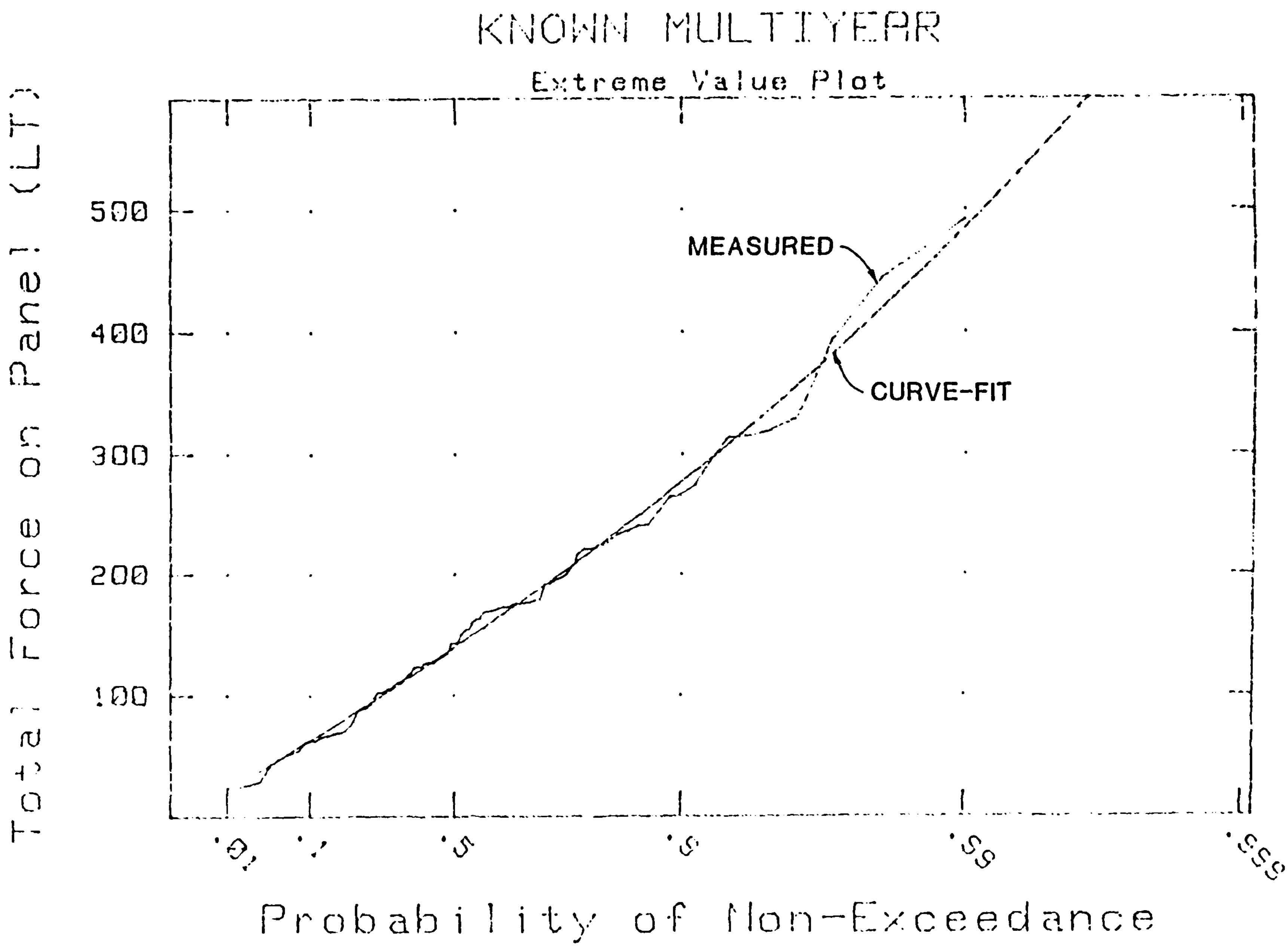
KNOWN MULTIYEAR
Extreme Value Plot
Total Force on Panel (LT)
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MEASURED
CURVE-FIT
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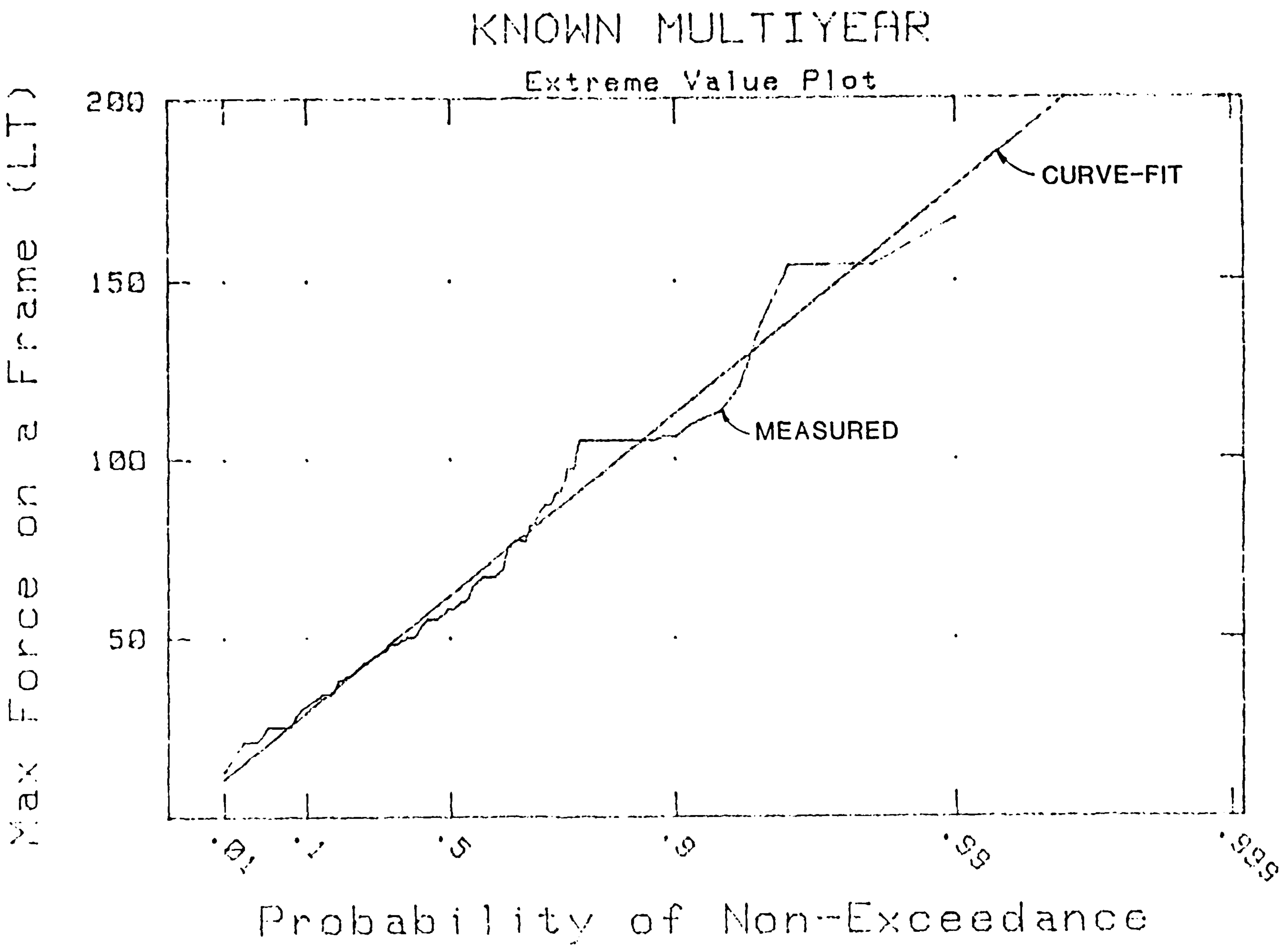
Probability of Non-Exceedance


KNOWN MULTIYEAR
Extreme Value Plot
Max Force on a Frame (LT)
200
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.01
.1
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.9
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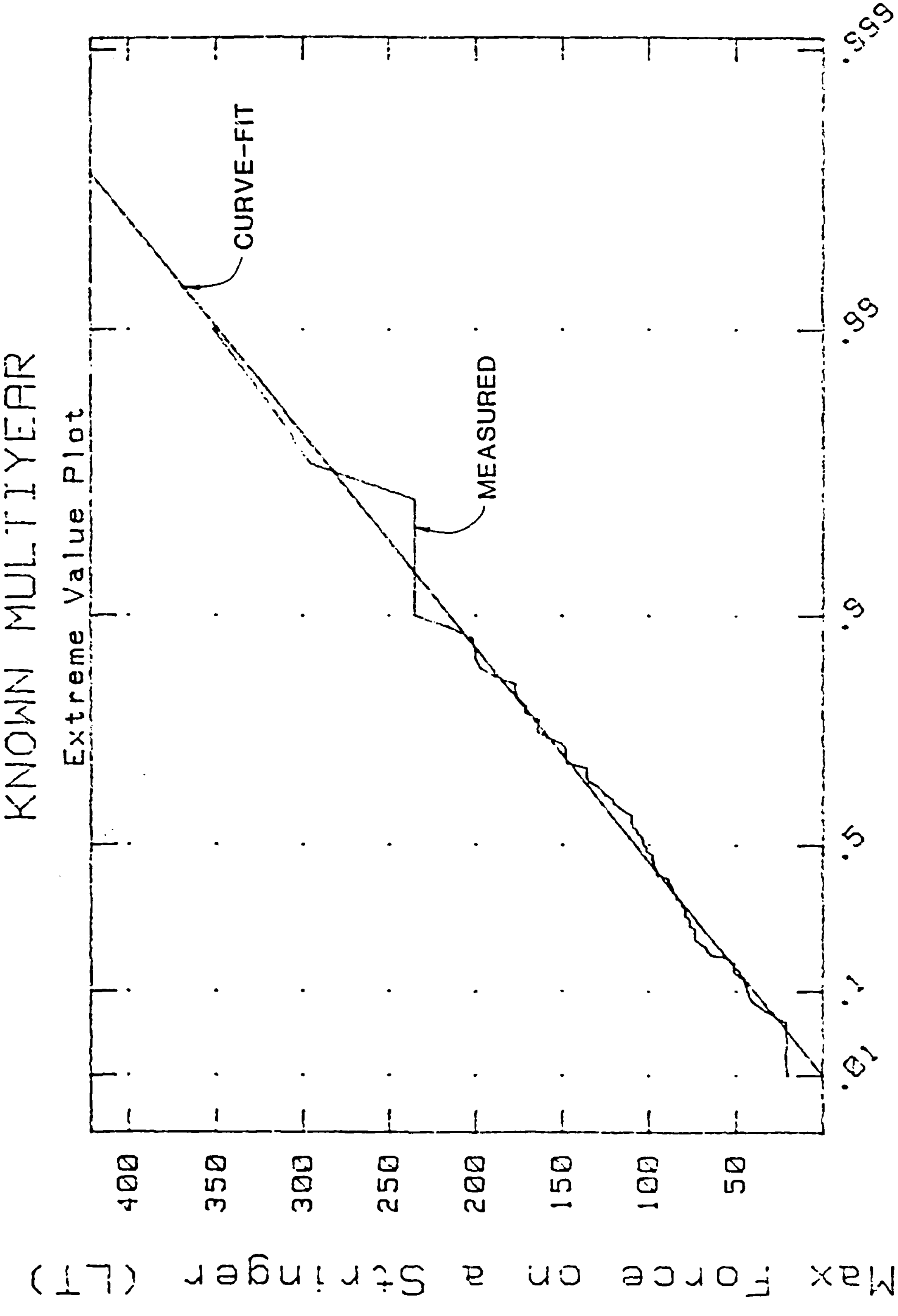
.995
Probability of Non-Exceedance
CURVE-FIT
MEASURED



KNOWN MULTIYEAR
Extreme Value Plot
CURVE-FIT
MEASURED
Max Force on a Stringer (LT)
400
350
300
250
200
150
100
50
Probability of Non-Exceedance
.01
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.5
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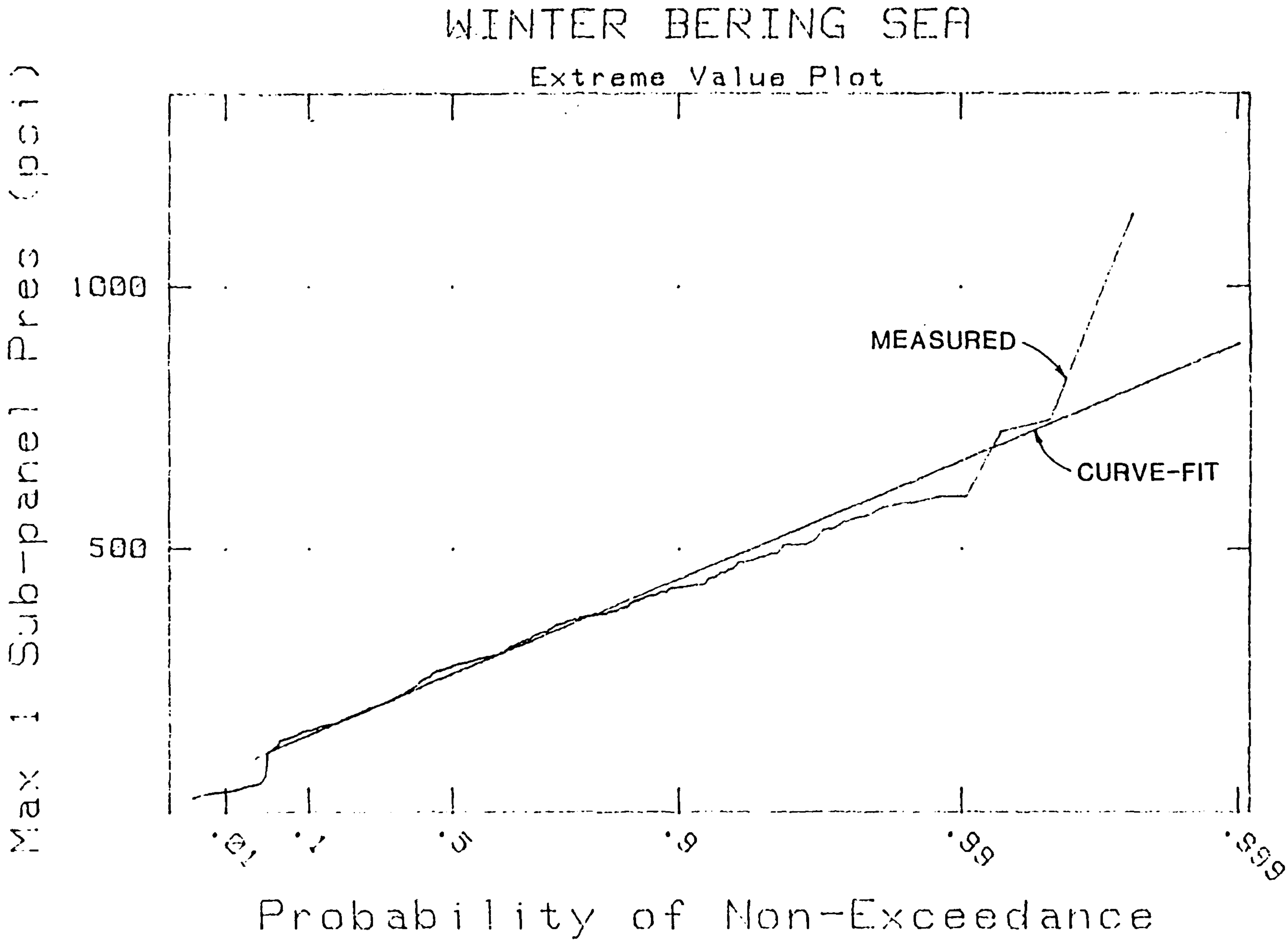
WINTER BERING SEA
Extreme Value Plot
Max I Sub-panel Pres (psi)
1000
500
MEASURED
CURVE-FIT
.01
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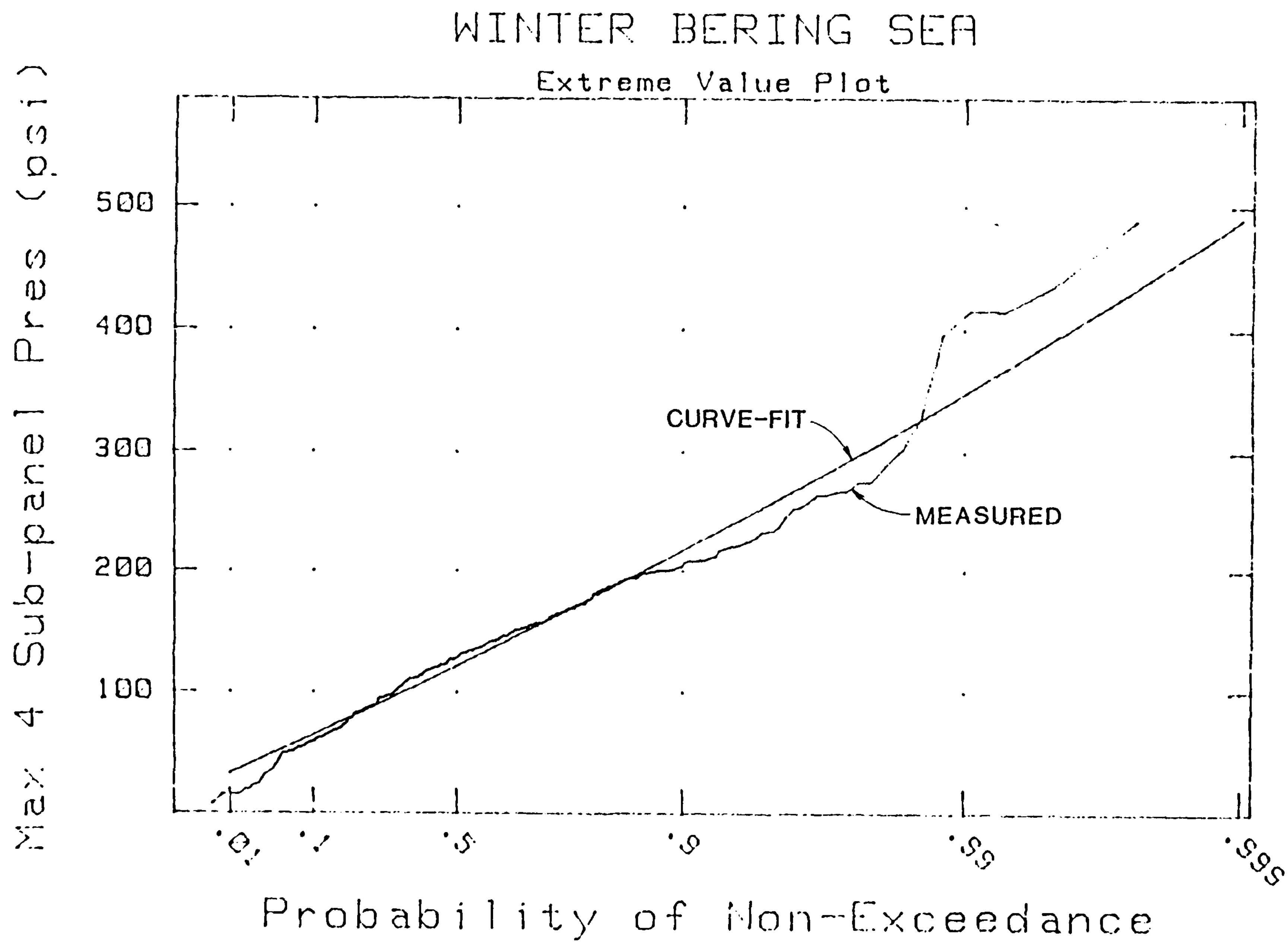
Probability of Non-Exceedance


WINTER BERING SEA
Extreme Value Plot
Max 4 Sub-panel Pres (psi)
500
400
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200
100
CURVE-FIT
MEASURED
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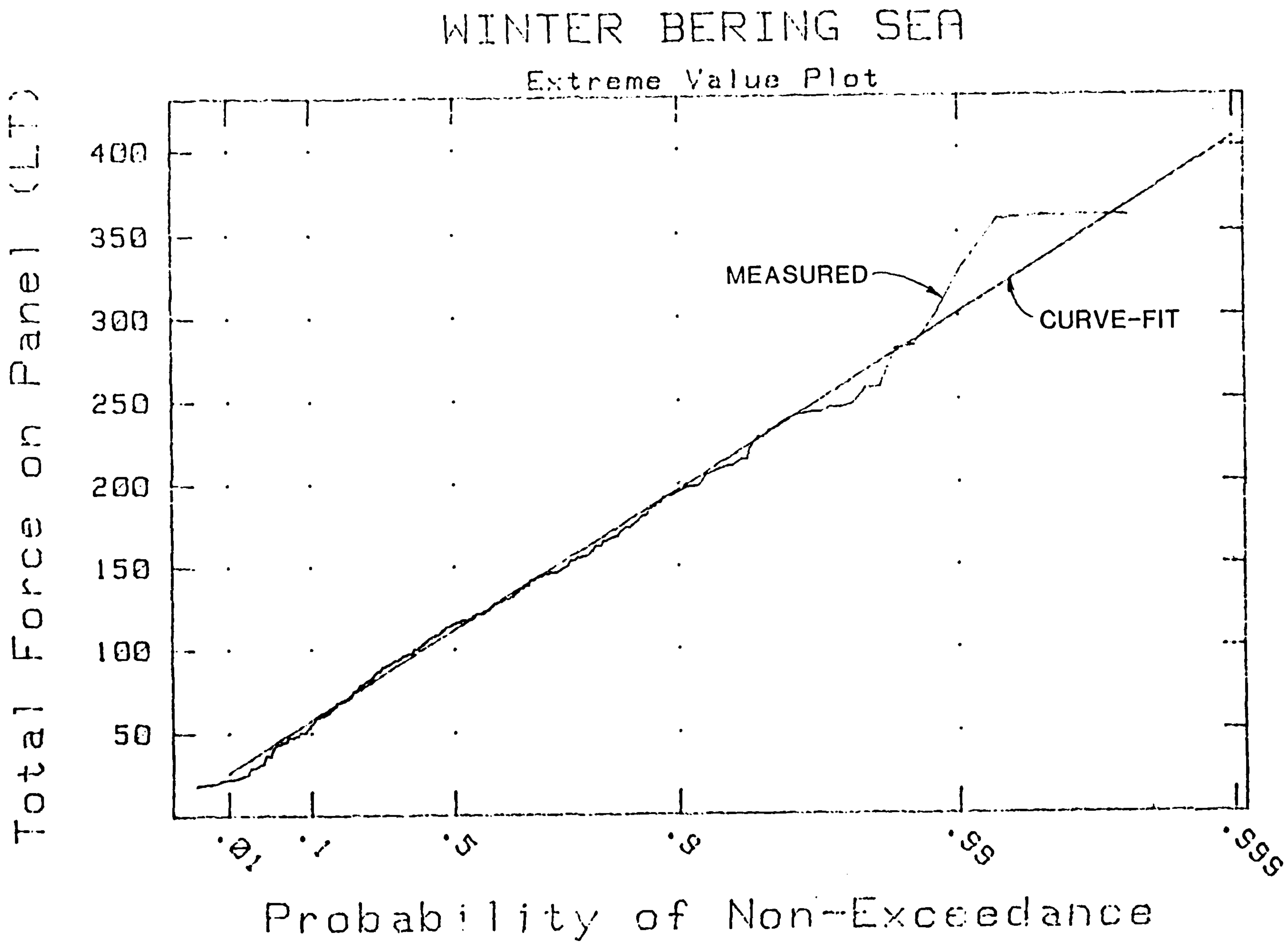
Probability of Non-Exceedance



WINTER BERING SEA
Extreme Value Plot
Total Force on Panel (LT)
400
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MEASURED
CURVE-FIT
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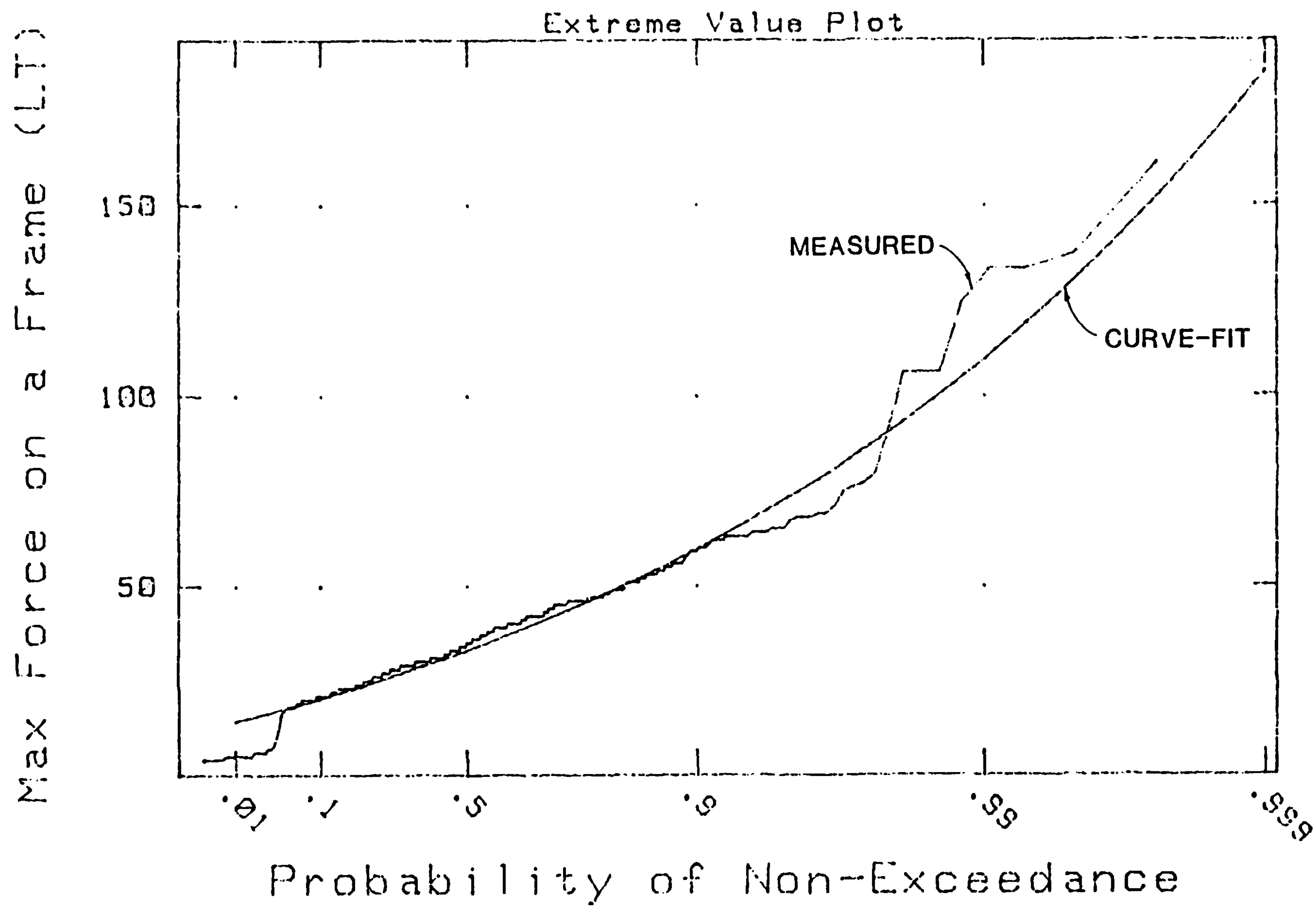
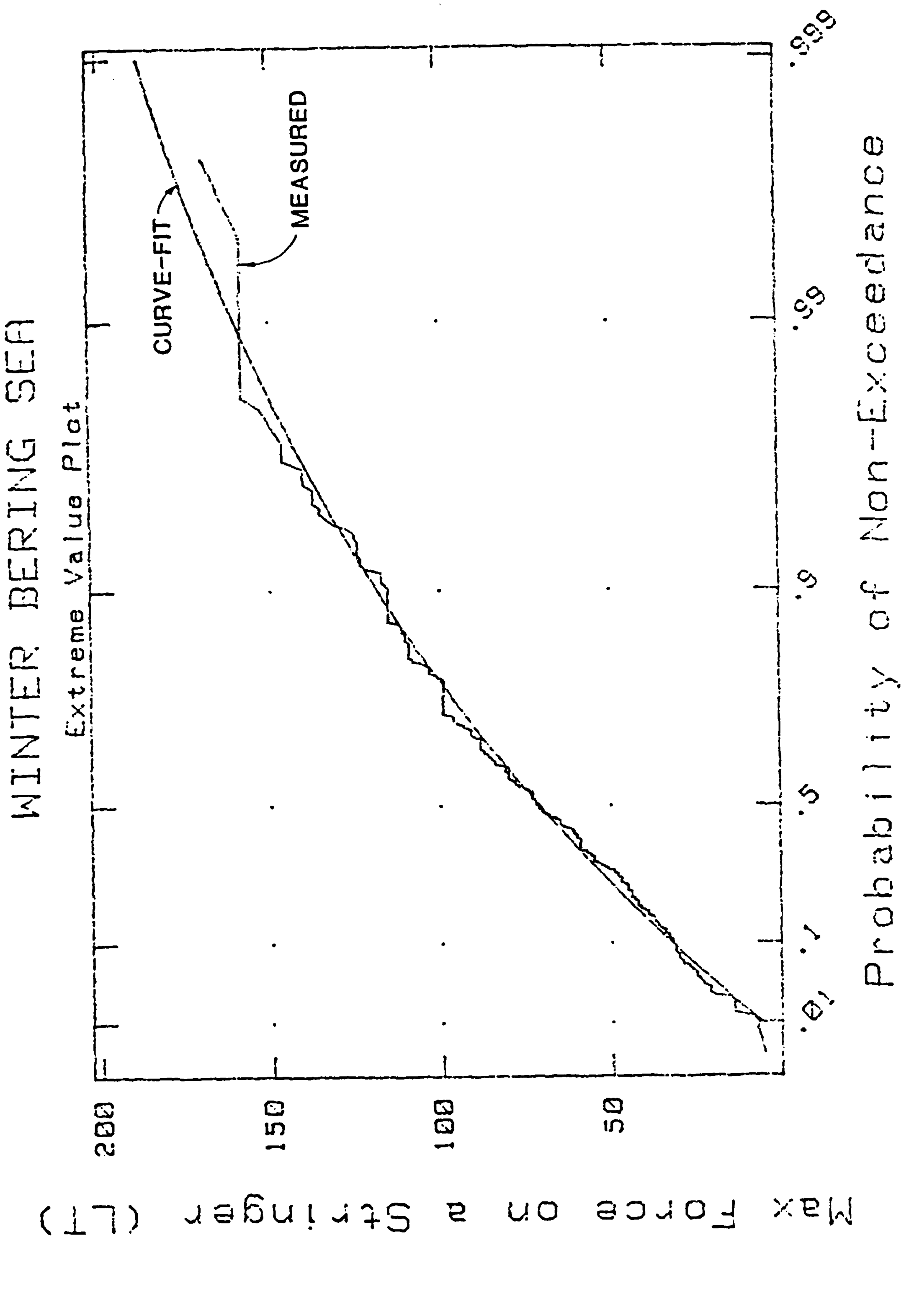
Probability of Non-Exceedance

WINTER BERING SEA




WINTER BERING SEA
Extreme Value Plot
CURVE-FIT
MEASURED
Max Force on a Stringer (LT)
200
150
100
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Probability of Non-Exceedance
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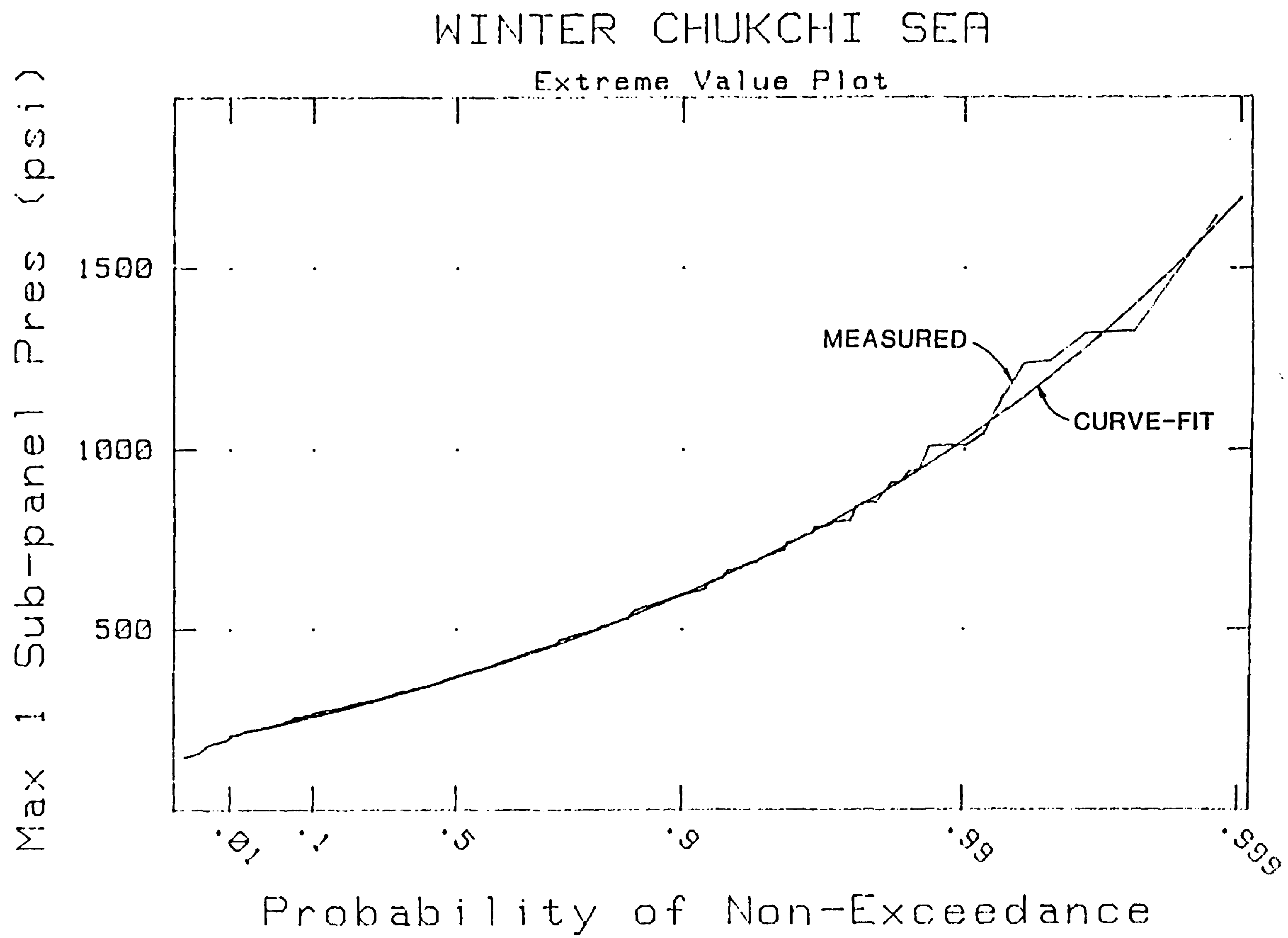
WINTER CHUKCHI SEA
Extreme Value Plot
Max 1 Sub-panel Pres (psi)
1500
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MEASURED
CURVE-FIT
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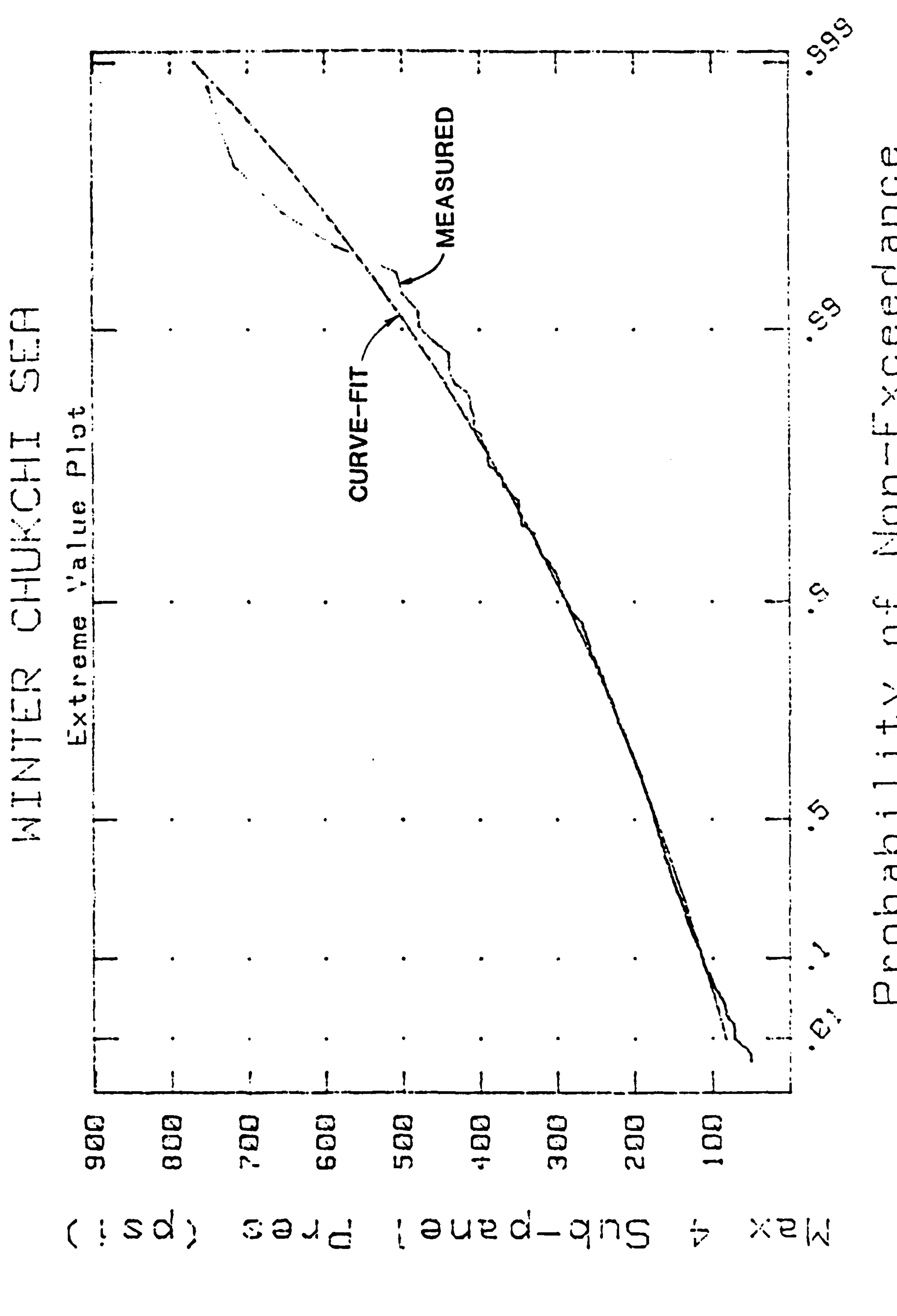
Probability of Non-Exceedance



WINTER CHUKCHI SEA
Extreme Value Plot
MEASURED
CURVE-FIT
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Max 4 Sub-panel Pres (psi)
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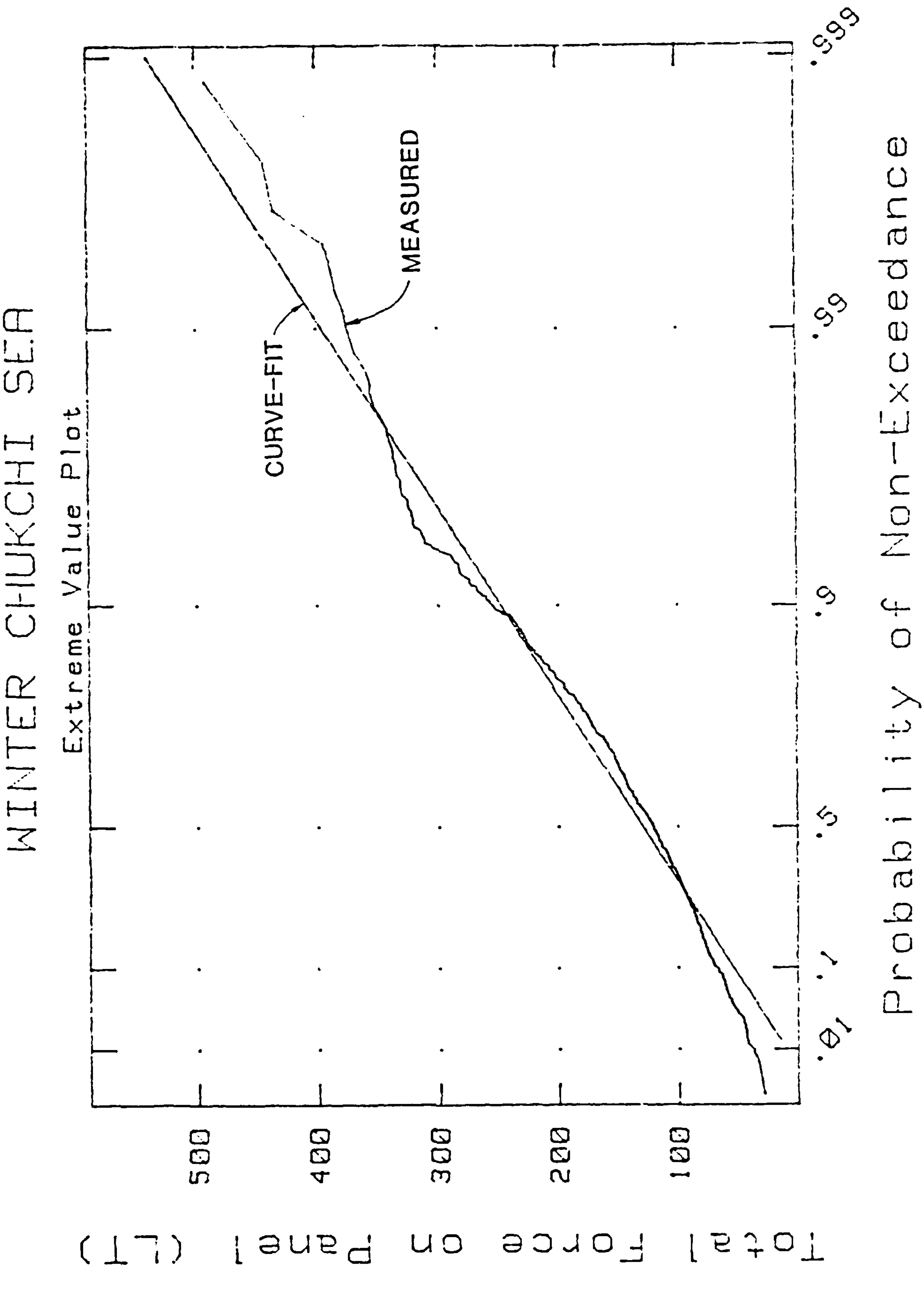
.999
Probability of Non-Exceedance



WINTER CHUKCHI SEA
Extreme Value Plot
MEASURED
CURVE-FIT
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Total Force on Panel (LT)
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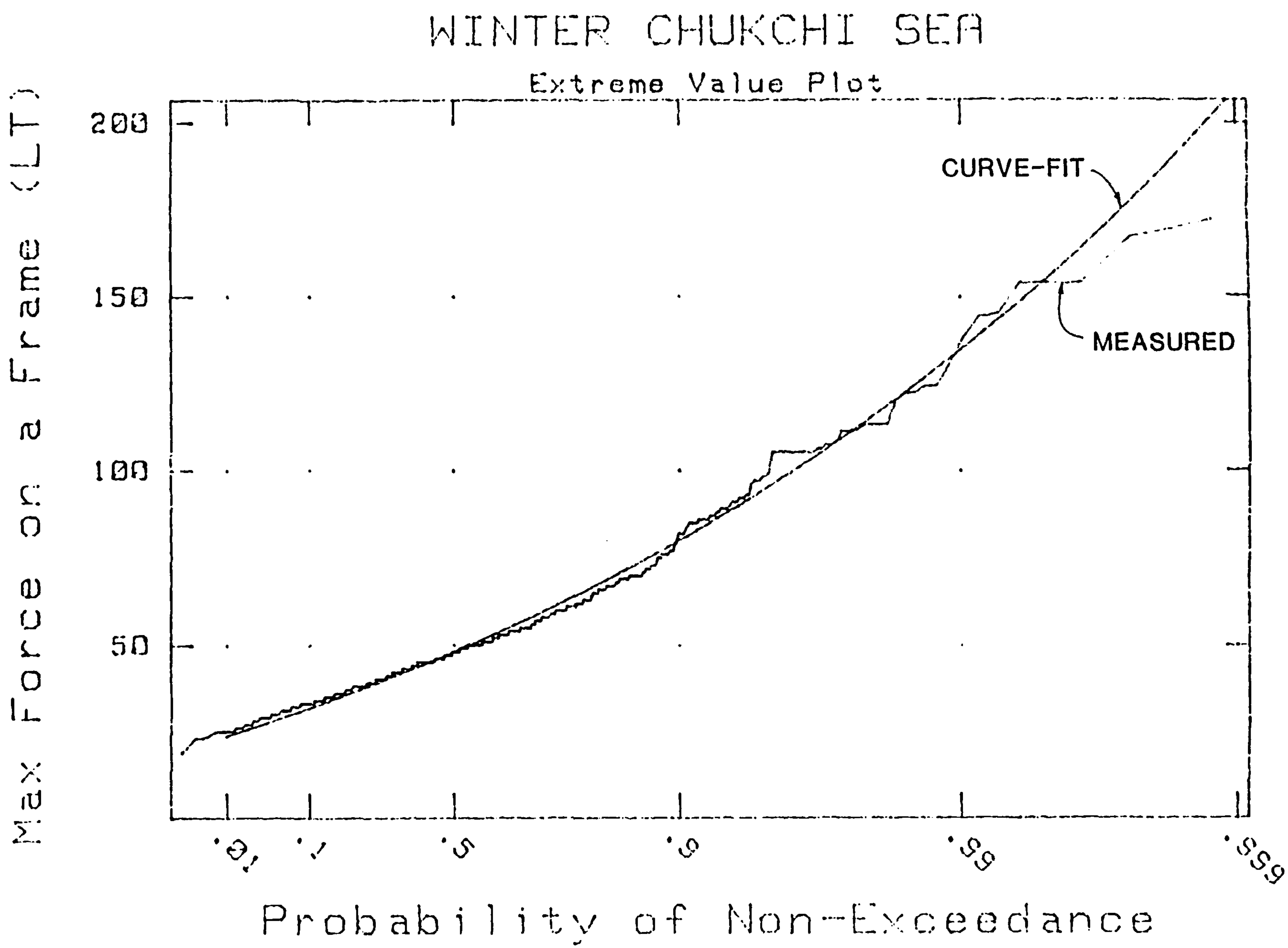
.999
Probability of Non-Exceedance


WINTER CHUKCHI SEA
Extreme Value Plot
Max Force on a Frame (LT)
200
150
100
50
CURVE-FIT
MEASURED
.01
.1
.5
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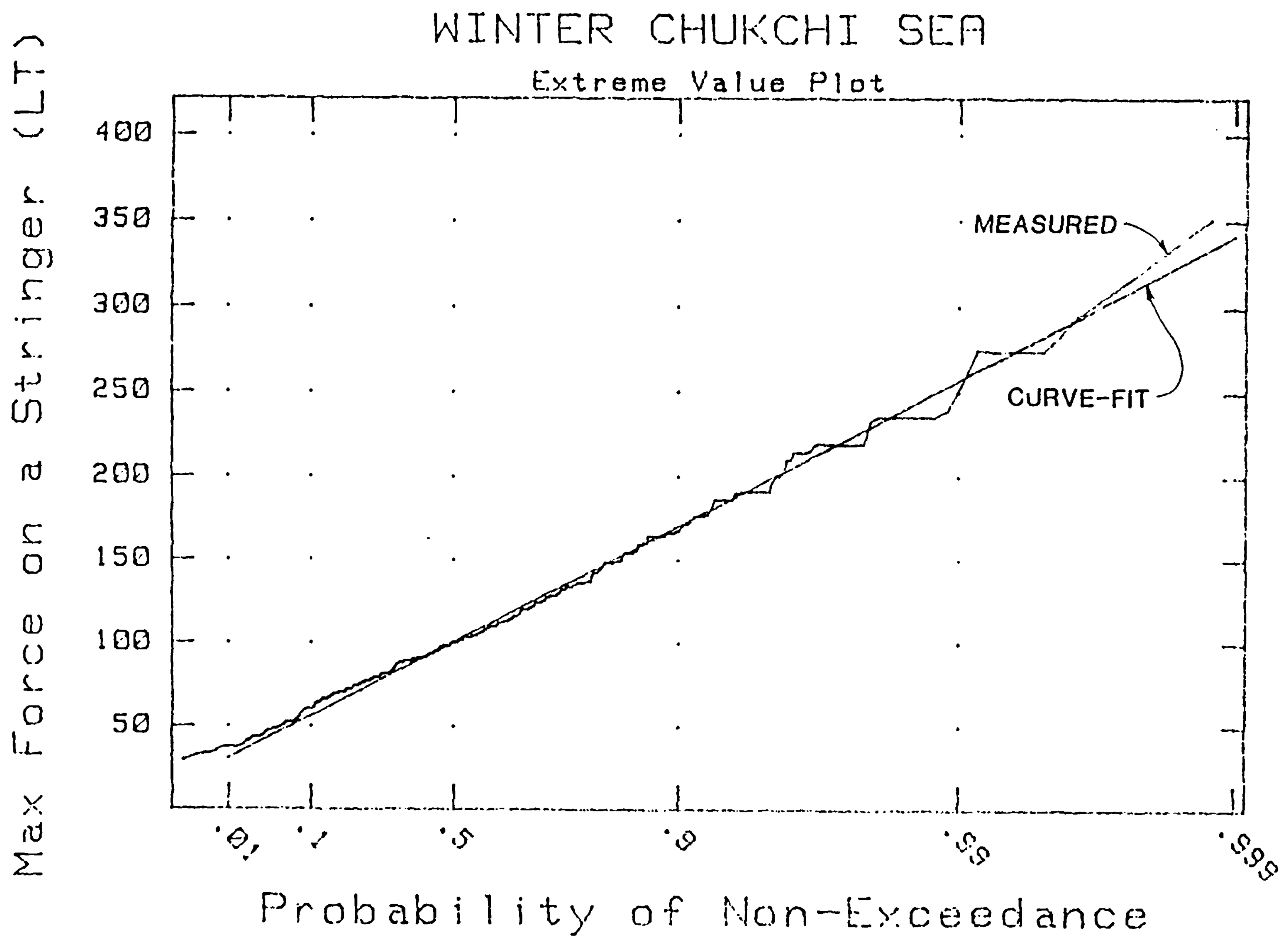
.999
Probability of Non-Exceedance



WINTER CHUKCHI SEA
Extreme Value Plot
MEASURED
CURVE-FIT
400
350
300
250
200
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100
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.5
.9
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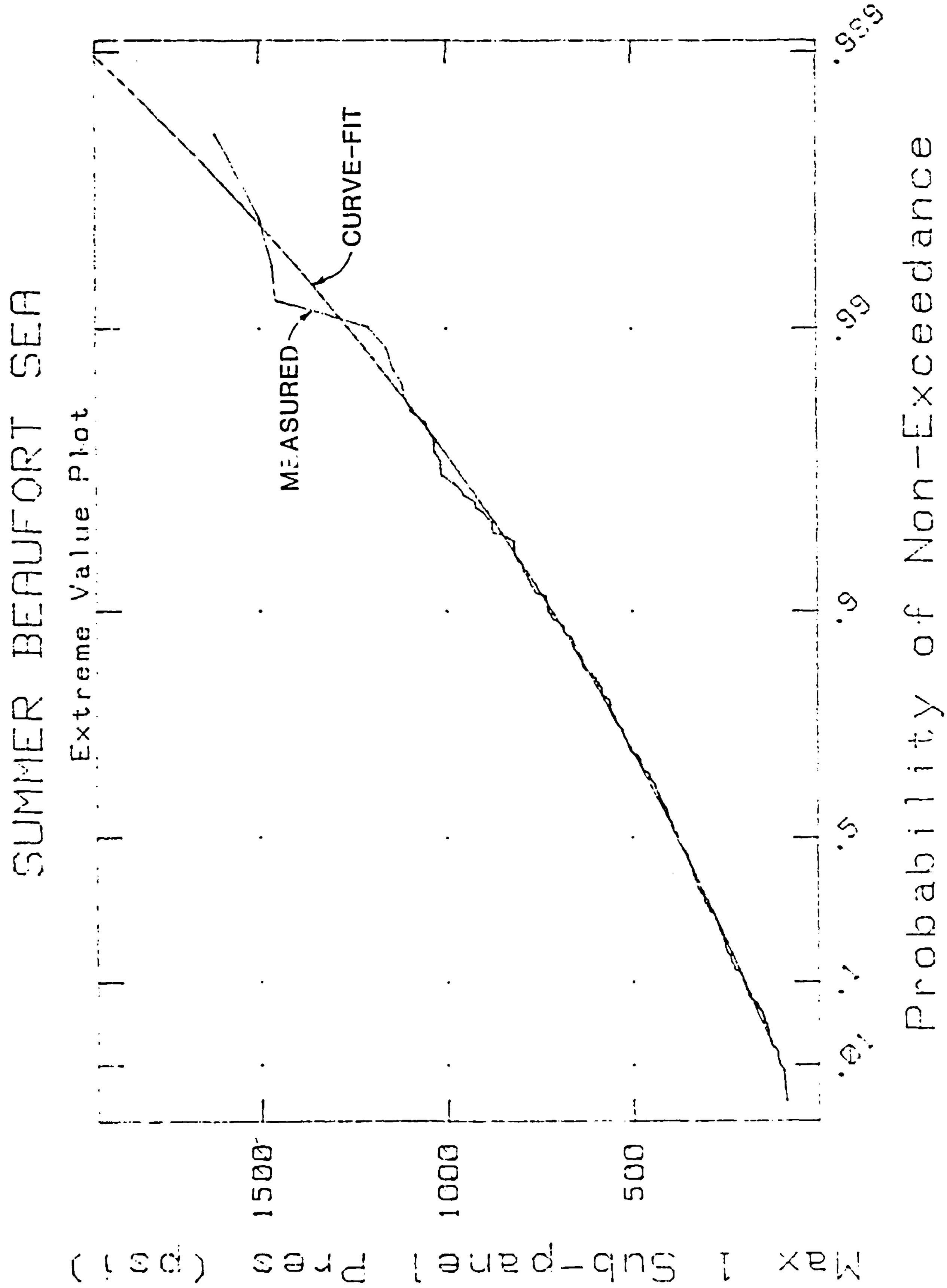
Probability of Non-Exceedance
Max Force on a Stringer (LT)



SUMMER BEAUFORT SEA
Extreme Value Plot
CURVE-FIT
MEASURED
1500
1000
500
Max I Sub-panel Pres (psi)
.01
.1
.5
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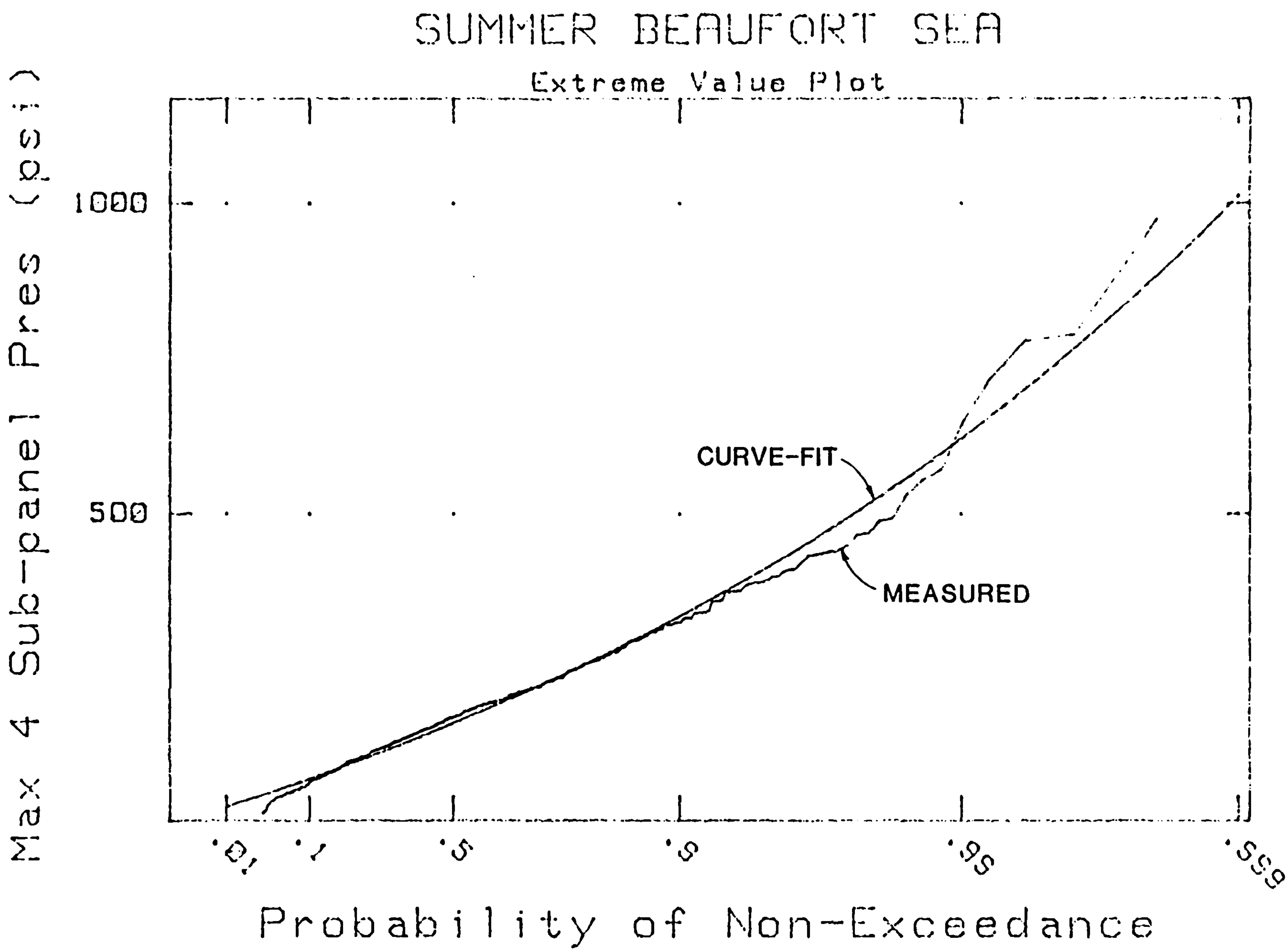
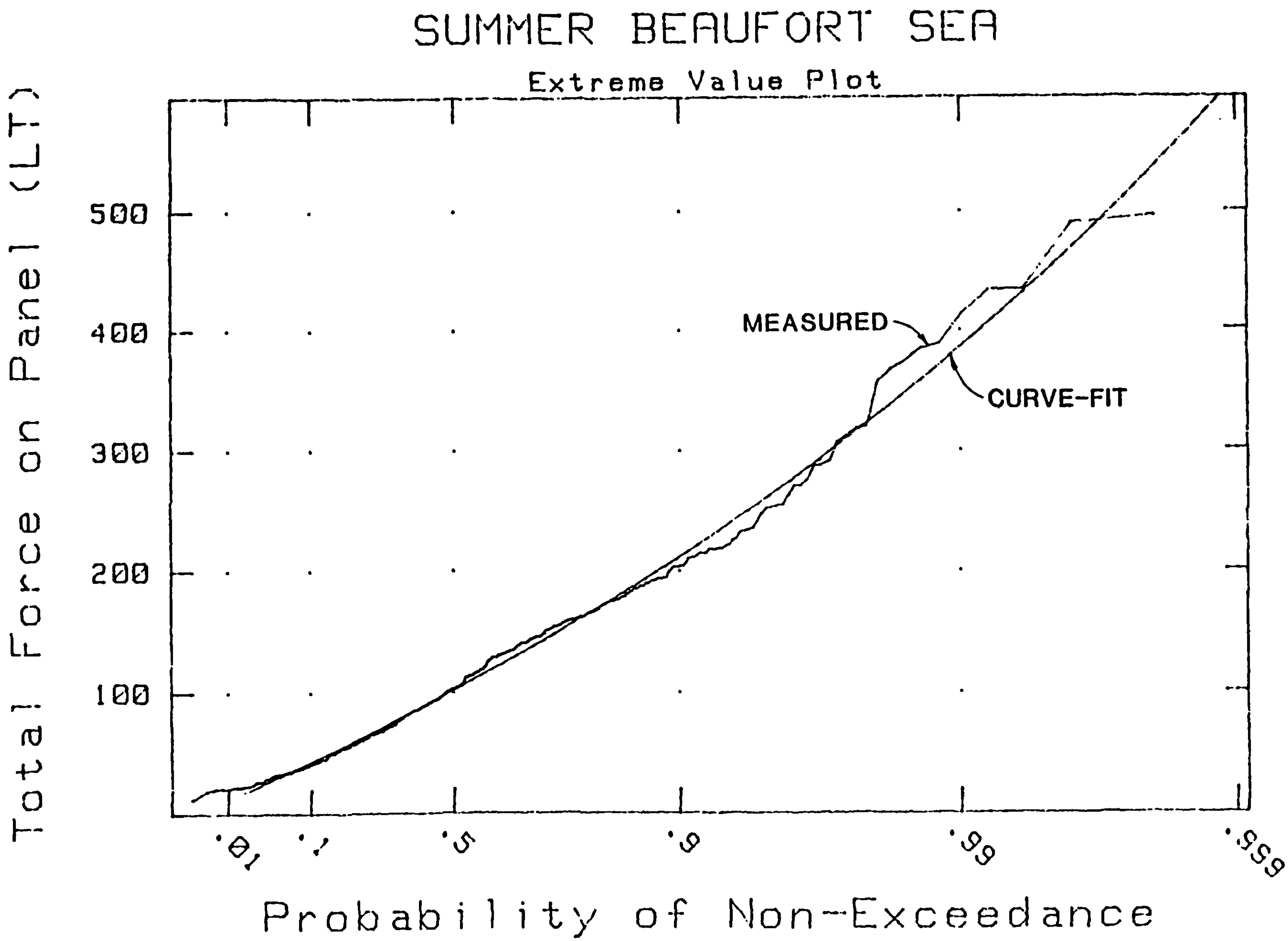
.99
.999
Probability of Non-Exceedance


SUMMER BEAUFORT SEA
Extreme Value Plot
Max 4 Sub-panel Pres (psi)
1000
500
.01
.1
.5
.9
.95
.995
Probability of Non-Exceedance
CURVE-FIT
MEASURED


SUMMER BEAUFORT SEA
Extreme Value Plot
Total Force on Panel (LT)
500
400
300
200
100
MEASURED
CURVE-FIT
.01
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.5
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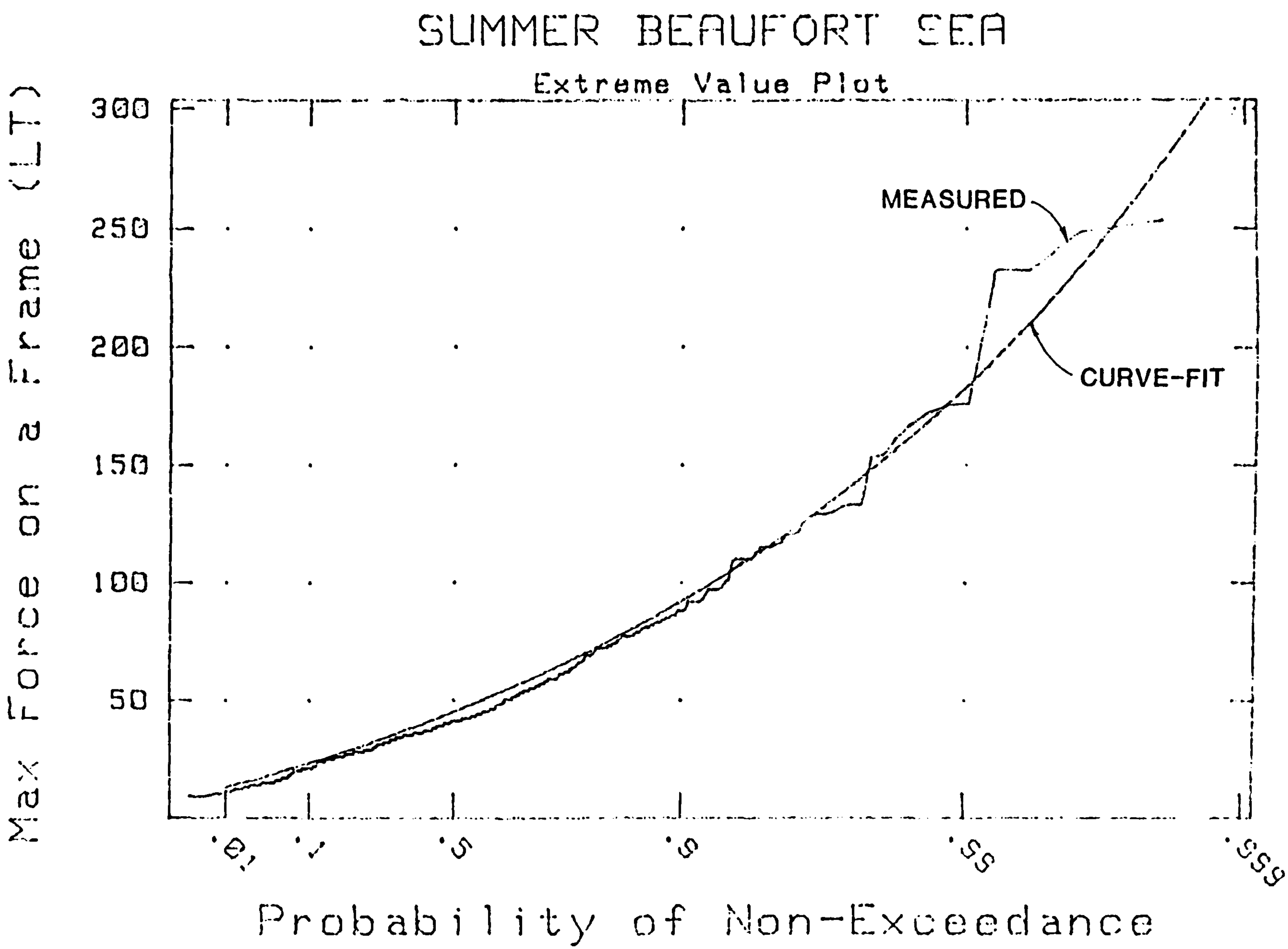
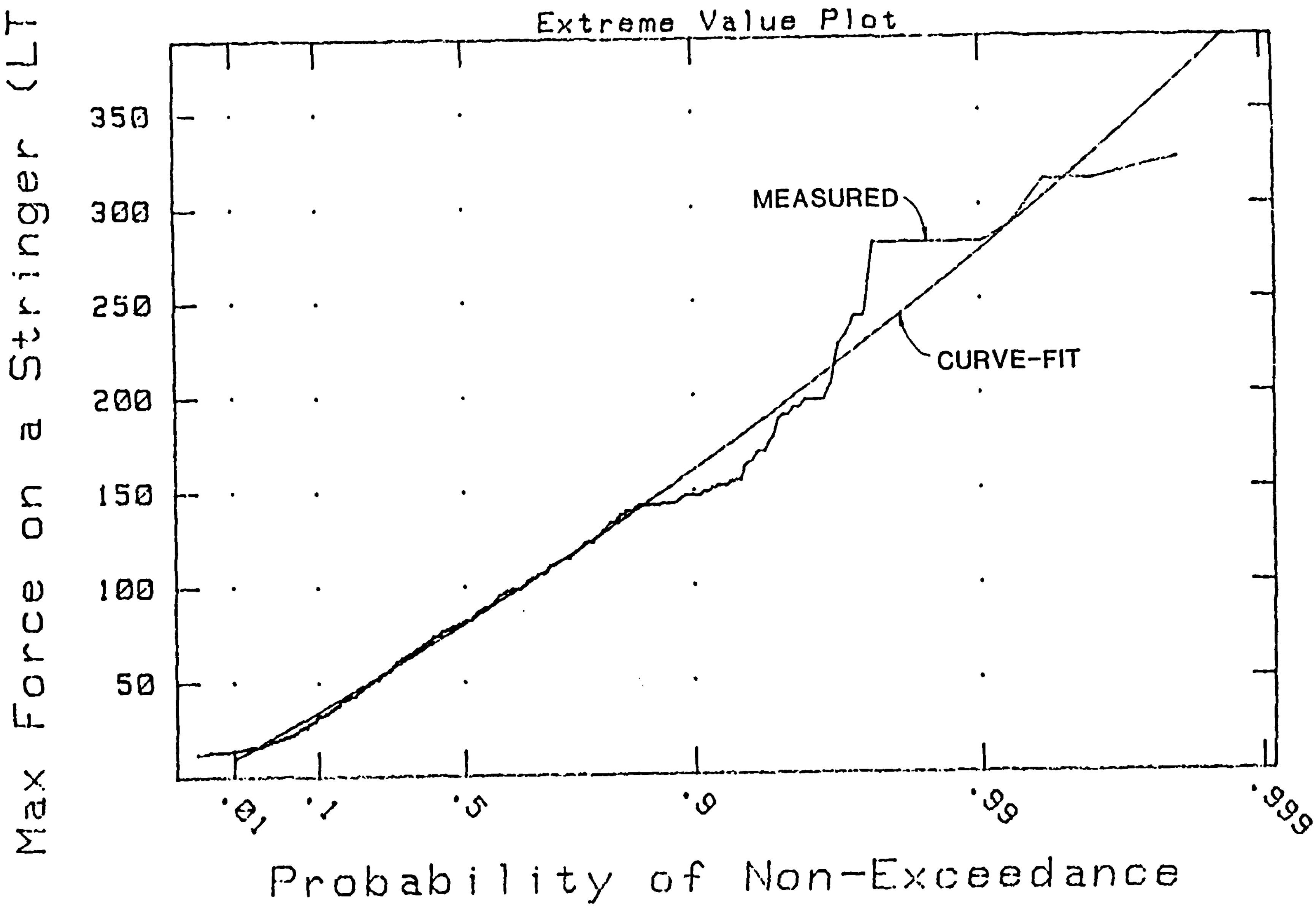
.99
.999
Probability of Non-Exceedance


SUMMER BEAUFORT SEA
Extreme Value Plot
MEASURED
CURVE-FIT
300
250
200
150
100
50
Max Force on a Frame (LT)
.01
.1
.5
.9
.99
.999
Probability of Non-Exceedance

SUMMER BEAUFORT SEA



APPENDIX D

SUMMARY OF TABLES OF THE COEFFICIENTS OF THE 3 PARAMETER CURVE FIT TO THE EXTREME VALUE DISTRIBUTIONS

TABLE D-1

REGRESSION COEFFICIENTS FOR THE 3 PARAMETER EXTREME VALUE DISTRIBUTION FOR HIGHEST AVERAGE PRESSURE ON A SINGLE SUB-PANEL

		REGRESSION COEFFICIENTS				
	NUMBER		A1		A2	
TITLE	OF EVENTS	C	MPa	psi	MPa	psi
Beaufort Summer 82	167	-.063	3.10	450	1.43	207
S Bering Winter 83	173	-.071	1.27	184	.35	51
N Bering Winter 83	241	.026	1.99	289	.58	84
S Chukchi Winter 83	299	-.218	2.01	291	.43	62
N Chukchi Winter 83	513	-.198	2.50	363	.71	103
Antarctic Summer 84	310	.042	1.90	276	.52	75
Beaufort Summer 84	337	.000	1.97	286	.83	121
N Chukchi Winter 83 MY	67	-.236	2.95	428	.95	138
Beaufort Summer 84 MY	32	-.247	1.96	284	.92	134
Known Multi-Year	266	.000	2.89	419	1.52	221
Heavy Mixed FY and MY	1017	-.128	2.37	343	.92	133
Known First-Year	723	.042	1.71	248	.63	91
Summer Beaufort Sea	504	-.116	2.22	322	1.06	154
Winter Chukchi Sea	812	-.193	2.28	330	.65	94
Winter Bering Sea	398	.000	1.56	226	.66	96

TABLE D-2

REGRESSION COEFFICIENTS FOR THE 3 PARAMETER
EXTREME VALUE DISTRIBUTION FOR
HIGHEST AVERAGE PRESSURE ON FOUR SUB-PANELS

TITLE	NUMBER OF EVENTS	REGRESSION COEFFICIENTS				
			A1		A2	
		C	MPa	psi	MPa	psi
Beaufort Summer 82	148	-.204	1.31	190	.60	87
S Bering Winter 83	154	.020	.56	81	.21	31
N Bering Winter 83	228	-.092	.86	125	.29	42
S Chukchi Winter 83	271	-.104	.88	128	.28	40
N Chukchi Winter 83	460	-.200	1.14	165	.33	48
Antarctic Summer 84	283	.101	.88	127	.23	34
Beaufort Summer 84	289	.055	.86	124	.43	62
N.Chukchi Winter 83 MY	63	-.322	1.31	190	.46	67
Beaufort Summer 84 MY	24	.071	.88	128	.52	75
Known Multi-Year	266	.001	1.21	175	.81	118
Heavy Mixed FY and MY	897	-.168	1.05	152	.41	60
Known First-Year	665	.005	.78	113	.28	40
Summer Beaufort Sea		-.136	.89	129	.53	77
Winter Chukchi Sea		-.149	1.05	153	.35	51
Winter Bering Sea		-.043	.72	104	.33	48

TABLE D-3

REGRESSION COEFFICIENTS FOR THE 3 PARAMETER
EXTREME VALUE DISTRIBUTION FOR
HIGHEST TOTAL FORCE ON THE PANEL

TITLE	NUMBER OF EVENTS	REGRESSION COEFFICIENTS C	A1 MN	A1 LT	A2 MN	A2 LT
Beaufort Summer 82	167	-.133	1.12	112	.62	62
S Bering Winter 83	173	.130	.96	96	.38	38
N Bering Winter 83	241	-.048	1.03	103	.45	45
S Chukchi Winter 83	299	-.052	.87	87	.37	37
N Chukchi Winter 83	513	-.016	1.23	123	.63	63
Antarctic Summer 84	310	-.005	.93	93	.30	30
Beaufort Summer 84	337	.000	.77	77	.46	46
N Chukchi Winter 83 MY	67	-.163	1.40	140	.60	60
Beaufort Summer 84 MY	32	-.028	.73	73	.52	52
Known Multi-Year	266	.001	1.08	108	.75	75
Heavy Mixed FY and MY	1017	-.043	1.04	104	.60	60
Known First-Year	723	-.048	.96	96	.36	36
Summer Beaufort Sea	504	-.114	.83	83	.50	50
Winter Chukchi Sea	812	.001	1.06	106	.63	63
Winter Bering Sea	398	.001	.95	95	.45	45

TABLE D-4

REGRESSION COEFFICIENTS FOR THE 3 PARAMETER
EXTREME VALUE DISTRIBUTION FOR
HIGHEST TOTAL FORCE ON A FRAME

TITLE	NUMBER OF EVENTS	REGRESSION COEFFICIENTS C	A1 MN	A1 LT	A2 MN	A2 LT
Beaufort Summer 82	167	.001	.56	56	.37	37
S Bering Winter 83	173	-.197	.22	22	.07	7
N Bering Winter 83	241	-.239	.36	36	.11	11
S Chukchi Winter 83	299	-.084	.39	39	.10	10
N Chukchi Winter 83	513	-.127	.46	46	.16	16
Antarctic Summer 84	310	.028	.33	33	.10	10
Beaufort Summer 84	337	.005	.30	30	.13	13
N Chukchi Winter 83 MY	67	-.033	.62	62	.26	26
Beaufort Summer 84 MY	32	-.127	.34	34	.18	18
Known Multi-Year	266	.001	.53	53	.35	35
Heavy Mixed FY and MY	1017	.005	.39	39	.26	26
Known First-Year	723	-.145	.31	31	.10	10
Summer Beaufort Sea	504	-.205	.38	38	.19	19
Winter Chukchi Sea	812	-.145	.43	43	.14	14
Winter Bering Sea	398	-.188	.29	29	.11	11

TABLE D-5

REGRESSION COEFFICIENTS FOR THE 3 PARAMETER
EXTREME VALUE DISTRIBUTION FOR
HIGHEST TOTAL FORCE ON A STRINGER

TITLE	NUMBER OF EVENTS	REGRESSION COEFFICIENTS C	A1 MN	A1 LT	A2 MN	A2 LT
Beaufort Summer 82	167	.001	.89	89	.55	55
S Bering Winter 83	173	.005	.41	41	.25	25
N Bering Winter 83	241	.234	.75	75	.30	30
S Chukchi Winter 83	299	.001	.73	73	.30	30
N Chukchi Winter 83	513	-.020	.98	98	.36	36
Antarctic Summer 84	310	.095	.69	69	.23	23
Beaufort Summer 84	337	.169	.60	60	.36	36
N Chukchi Winter 83 MY	67	.001	1.13	113	.55	55
Beaufort Summer 84 MY	32	.210	.52	52	.32	32
Known Multi-Year	266	.001	.89	89	.54	54
Heavy Mixed FY and MY	1017	.006	.81	81	.41	41
Known First-Year	723	.170	.64	64	.29	29
Summer Beaufort Sea	504	-.066	.66	66	.39	39
Winter Chukchi Sea	812	.001	.87	87	.37	37
Winter Bering Sea	398	.165	.60	60	.31	31

APPENDIX E

DESIGN OF SHELL PLATING ON ICEBREAKERS

Failure of shell plating can be defined in several ways:

- initial yielding
- unacceptable deformation (permanent set)
- rupture (after large deformation)
- fatigue

Initial yielding is not normally considered as failure in icebreakers. No visible damage results from yielding. As well, design against initial yielding would be unnecessarily costly. Fatigue considerations are normally dealt with through proper selection of steel grades.

For modern icebreakers, constructed of high strength and highly ductile steels, the design condition is some level of permanent set that is considered acceptable. For these steels the rupture strength is very high and is of less interest.

Post yield behavior of plating depends on a number of parameters and mechanisms:

- plastic hinge formation at edges
- plastic hinge formation at center
- membrane action due to deflection
- lateral deflection of plate edges
- "pulling out" of plastic hinges under high membrane loads
- plate aspect ratio
- plate slenderness ratio
- load shape
- load relaxation due to deformation

The complexity of the plastic response of the plate, together with scarcity of experimental data, has so far resulted in a diverse range of opinions and equations in the literature. This report will discuss the various approaches and propose a suitable basis for design of shell plating.

- stress strain model
- yield criteria
- ultimate strain at rupture

Timoshenko [1] studied long flat plates with built in and simply supported edges. All of his solutions considered elastic action only. His solutions considered the membrane stresses resulting from laterally restrained supports. This work provided the basis for later plasticity analysis.

Clarkson [2] considered the elastic and plastic response of rigid clamped plates of various aspect ratios, up to the formation of a single plastic hinge at the edge (including membrane action). Clarkson's equation (for zero aspect ratio) is:

$$p = 4.56 \left[\sigma_y^{4/3} / E^{1/3} \right] \cdot (t/s)^{4/3} \qquad (F.1)$$

p = applied load (capacity)

σ_y = yield strength

E = Young's Modulus

t = plate thickness

s = plate span (frame spacing)

The resulting permanent deformation was equal to those caused by the welding process during fabrication.

Johansson [3] considered a three plastic hinge mechanism as the design condition. He assumed that membrane stresses would not be important and that (practically) no permanent deformation would result. His strength formula is:

$$p = 4\, \sigma_y \left(\frac{t}{s} \right)^2 \qquad (F.2)$$

Hooke [5] based on the experimental results of Hooke and Rawlings [4], extended Clarkson's work on fixed edged plates of non-zero aspect ratio. In [4] it is noted that the tests were unable to prevent lateral movements of the plate boundaries.

Jones [6] examined finite plastic deflection of rectangular plates with simply supported and fully clamped edges. Using a rigid perfectly plastic stress model and

assuming no lateral deflections at the boundaries, he produced the following formula for the fully clamped case:

$$p = \bar{p}_c \cdot \left[1 + \frac{1}{3} \left(\frac{W}{t}\right)^2 \left\{ \frac{\zeta + (3-2\zeta)^2}{(3-\zeta)} \right\} \right] \qquad (F.3)$$

where $W \leq t$

$$\bar{p}_c = 12\,\sigma_y \left(\frac{t}{s}\right)^2 \frac{1}{\left(\sqrt{3+\alpha^2} - \alpha\right)^2} \qquad \text{(3 hinge load)}$$

$$\zeta = \alpha \left\{ \sqrt{3+\alpha^2} - \alpha \right\}$$

α = s/a (aspect ratio)

a = height of plate

W = permanent deflection

(Note that (F.3) reduces to (F.2) when α and W are equal to 0).

For the simply supported case:

$$p = \bar{p}_c \left[1 + \frac{4}{3} \left(\frac{W}{t}\right)^2 \left\{ \frac{\zeta + (3-2\zeta)^2}{(3-\zeta)} \right\} \right] \qquad (F.4)$$

$$W < t/2$$

or

$$p = \frac{\bar{p}_c}{2} \frac{4W}{t} \left[1 + \frac{\zeta(\zeta-2)}{3-\zeta} \left(1 - \frac{t^2}{12W^2} \right) \right] \qquad (F.5)$$

$$W > t/2$$

for plates of zero aspect ratio this reduces to:

$$p = 8\,\sigma_y \left(\frac{t}{s}\right) \left(\frac{w}{s}\right) \qquad (F.6)$$

Coburn et al [7] took equation (F.3) for W/t = 1, $\alpha = 0$ to obtain

$$p = 8\,\sigma_y \left(\frac{t}{s}\right)^2 \qquad (F.7)$$

and suggested a plate design (inverting (F.7)) of;

$$t = .353\, s \sqrt{P/\sigma_y}$$

Coburn et al also reports that Clarkson's equation (F.1) if extended to 3 plastic hinges would become approximately

$$P = 9.12 \left[\sigma_y^{4/3} \Big/ E^{1/3} \right] \left(\frac{t}{s}\right)^{4/3} \qquad (F.8)$$

Hughes [8] in a very comprehensive paper, developed a solution for plastic plate response based on an elastic-perfectly plastic stress model and allowing for the freedom of the edges to pull in (Figure 1). Hughes defines the slenderness ratio β as;

$$\beta = s/t \sqrt{\sigma_y/E} \qquad (F.9)$$

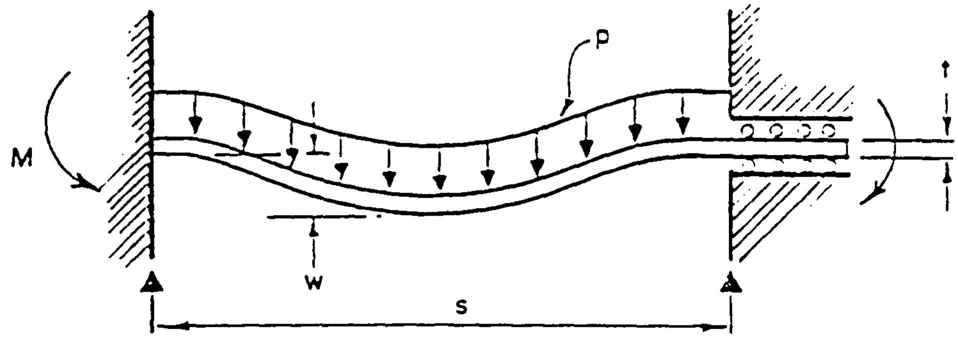


Figure 1 ASSUMED CONDITION of PLATING for ANALYSIS by HUGHES [8]

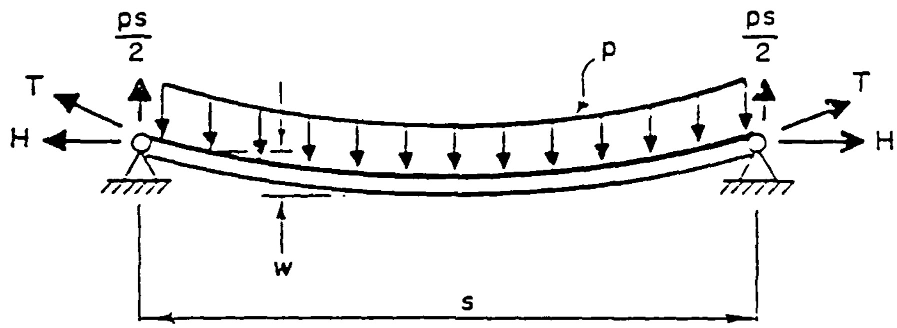


Figure 2 IDEAL MEMBRANE BEHAVIOUR of PLATE

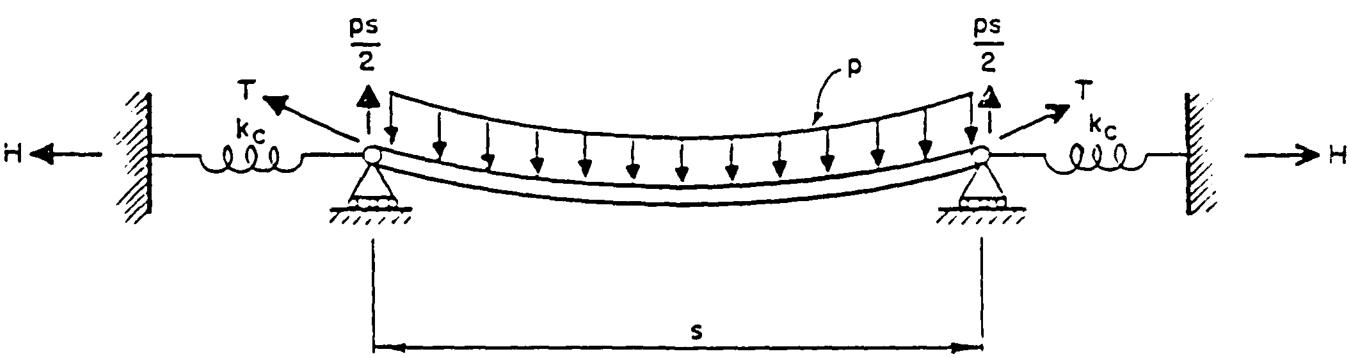


Figure 3 MEMBRANE BEHAVIOUR in the PRESENCE of SPRINGS

Hughes explains that for sturdy plates ($\beta < 2.4$) the deflections under load will be quite small and, because of the occurrence of edge pull-in, that membrane effects are small even after yielding. It is noted that plates on icebreakers are very sturdy (i.e. s = 400 mm, t = 36 mm, σ = 360 will result in $\beta = .46$!) and that edge pull-in could be very important. As a result membrane stresses would be small. Using a non-dimensional load parameter Q;

$$Q = pE/\sigma_y^2 \tag{F.10}$$

Hughes developes a 3 part expression for the load/deformation equation:

$$Q = Qy + K_w\,(\Delta Q_0 + \Delta Q_1 \cdot R_w) \tag{F.11}$$

in which;

Qy = nondimensional load at initial yield

ΔQ_0 = increase in load up to full formation of the edge hinge

ΔQ_1 = slope of Qvs W_p/Wp_0 after edge hinge

$R_w = W_p/W_{p0}$

$K_w = 1 \qquad R_w > 1$

$= (1-(1-R_w)^3)^{1/3} \qquad R_w < 1$

Wp = permanent deformation

Wp_0 = permanent deformation at completion of edge hinge formation

$\approx .07\beta^2 t$

Equation (F.11) is based on small deflection theory and is valid for $Wp_0 < Wp < t$. Equation (F.11) considers the steel to follow Hencky-VonMises yield criteria. The equation includes the effects of non zero aspect ratios. The complete equations are as follows:

$$Q_y = \frac{2}{\sqrt{1 - \nu + \nu^2 \beta^2}} \left(1 + 0.6 \, (\alpha)^4 \right) \qquad (F.12)$$

$$\Delta Q_0 = 1 + .5\beta \; \frac{\alpha \, (1 + \alpha \, (3.3 - 1/\beta)}{\sqrt{1 - \nu + \nu^2 \beta^2}} \qquad (F.13)$$

$$\Delta Q_1 = .95 \; \left[\alpha / \sqrt{\beta} \right]^{1.5} \qquad (F.14)$$

For $\alpha = 0$, this reduces to

$$Q = \frac{3}{\sqrt{1 - \nu + \nu^2 \beta^2}} \qquad (F.15)$$

or

$$P = 3.46 \; \sigma_y \left(\frac{t}{s} \right)^2 \qquad (F.16)$$

For $\alpha = .2$, $\beta = .46$, and $W_p = t$, (F.11) reduces to

$$Q = \frac{3.06}{\sqrt{1 - \nu + \nu^2 \beta^2}} + .15 \frac{W_p}{W_{p_0}} \qquad \text{(F.17)}$$

$$P = 3.44 \, \sigma_y \left(\frac{t}{s}\right)^2 + 2.14 \, \sigma_y \left(\frac{t}{s}\right)^2 \left(\frac{W_p}{t}\right)$$

$$= 5.58 \, \sigma_y \left(\frac{t}{s}\right)^2 \qquad \text{(F.18)}$$

To examine the edge pull-in, consider first the limiting condition of membrane behaviour. Figure 2 illustrates ideal membrane behaviour with pinned ends. Ratzlaff and Kennedy [9] provide a clear discussion of the ideal membrane situation (as well as a very informative discussion of many aspects of the problem). It can easily be shown that for the case shown in Figure 2

$$P = \frac{8 W T}{\sqrt{s^4 + (4Ws)^2}} \qquad \text{(F.19)}$$

T = Membrane Tension

This is true for any stress condition (elastic or plastic) as long as the membrane tension T is constant throughout the plate. The increase in length due to the sag is given by λ;

$$\lambda = \frac{8}{3} \frac{W^2}{s} \qquad \text{(F.20)}$$

again, regardless of the state of stress.

For the elastic condition, the strain is given by ε;

$$\varepsilon = \lambda/s \tag{F.21}$$

the stress σ is;

$$\sigma = \frac{\varepsilon E}{(1-\nu^2)} = \frac{\lambda E}{s(1-\nu^2)} = \frac{8}{3}\,\frac{W^2}{s^2}\,\frac{E}{(1-\nu^2)} \tag{F.22}$$

which leads to the membrane tension of

$T = st$

and combining this result with F.22

$$T = \frac{8}{3}\left(\frac{W}{s}\right)^2 \frac{Et}{(1-\nu^2)} \tag{F.23}$$

Therefore using (F.19), the load vs. deflection is

$$P = \frac{64}{3}\left(\frac{W}{s}\right)^3 \frac{Et}{(1-\nu^2)}\,\frac{1}{\sqrt{s^2 + (4W)^2}} \tag{F.24}$$

This elastic solution is only valid up to the yield stress, at which the deflection is:

$$Wy = \sqrt{\frac{3\ \sigma_y\ (1-\nu^2)}{8\ E}} \cdot s \tag{F.25}$$

which for σ = 360 MPa is;

$$Wy = 0.025 \cdot s \tag{F.26}$$

For deflections above Wy, the tension becomes constant at the yield value $(T = \sigma yt/(1-vp^2))$ which results in a load vs. deflection equation of:

$$P = \frac{8\,\sigma_v}{\left(1-vp^2\right)} \left(\frac{W}{s}\right)\left(\frac{t}{s}\right) \frac{1}{\sqrt{1 + \left(\frac{4W}{s}\right)^2}} \qquad (F.27)$$

where vp = plastic Poissons ratio

= .5

It is necessary to examine the assumption of edge pull-in. To do this the neighbouring plate is considered as a spring (as in Figure 3). To get the value of the spring constant, assume that the plates to either side are semi-infinite and edge loaded over a length of a. Timoshenko [10] gives the solution for this condition. The deflection of the center of the load is:

$$\delta = \frac{2\,q}{\pi\,E}\,(a \log a/2) \qquad (F.28)$$

which means that the stiffness (for plates on both sides combined) is:

$$K_e = \frac{\pi\,E\,t}{4 \log (a/2)} \qquad (F.29)$$

The stiffness of the plate itself is determined using equations (F.20 and F.21).

$$K_p = T/\lambda \cdot a$$

$$= \frac{\frac{8}{3}\left(\frac{W}{s}\right)^2 \frac{E\,t}{(1-\nu^2)} \cdot a}{\frac{8}{3}\frac{W^2}{s}}$$

$$K_p = \frac{E\ \ t \cdot a}{s\ (1-\nu^2)} \qquad (F.30)$$

It is possible to combine K_p and K_e and simply consider the ideal membrane case (Figure 2) but with a more flexible plate of the combined stiffness K_c, is

$$K_c = 1/(1/K_p + 1/K_e)$$

$$= K_p\ (1/(1 + K_p/K_e))$$

$$= K_p\ \theta \qquad (F.31)$$

$$\theta = 1/(1 + 1.4\ \frac{a\ \log\ a/2}{s} \qquad (F.32)$$

by determining T from $K_c \cdot \lambda$, a modified load vs. deflection equation:

$$p = \frac{64}{3} \left(\frac{W}{s}\right)^3 \frac{E\,t}{(1-\nu^2)} \frac{\theta}{\sqrt{s^2 + (W)^2}} \qquad (F.33)$$

Note that (F.33) is only (24) times θ. Essentially E can be replaced by E θ to simulate the edge springs. Again the elastic solution is only valid up to the yield stress, at which point the deflection is;

$$W_y = \sqrt{\frac{3\,\sigma_y}{8\,E\,\theta}} \cdot s \qquad (F.34)$$

$$\theta = 1/\left(1 + 1.4\ \frac{a \log a/2}{s}\right)$$

Given $\sigma_y = 360$

$a = 1.2$ m

$a/s = 4$

The onset of full membrane action would take place at a deflection of

$$W = .036 \cdot s \qquad (F.35)$$

Any deflection greater than 3.6% of the frame span would result in complete plasticity and therefore complete membrane action. This simplifies the problem greatly because T becomes constant at $\sigma_y t/(1-\nu_p^2)$. Again utilizing (F.19) the load/deflection equation for a full plastic membrane is:

$$p = 8\,W \cdot \frac{\sigma_y t}{(1-\nu_p^2)} \frac{1}{\sqrt{s^4 + (4Ws)^2}}$$

or

$$p = 10.67 \left(\frac{W}{s}\right) \sigma_y \left(\frac{t}{s}\right) \frac{1}{\sqrt{1 + (4\ W/s)^2}} \qquad \text{(F.36)}$$

for W/s = 0.1

$$p = 0.99\ \sigma_y \frac{t}{s} \qquad \text{(F.37)}$$

It is worth noting that when the full plastic membrane stress is activated, the plastic hinge at the edge of the plate is completely pulled out resulting in no edge moment, and the ideal membrane condition upon which equation (F.37) depends. Note also that (F.36) is almost identical to (F.6), which would be expected, since both involve both membrane action. In fact, equation (F.5) probably best describes the action of plates subject to large deflections and has the advantage of considering non zero aspect ratios. As a result it is suggested that a suitable design criteria would be some ratio of permanent set (W) to frame

spacing. The required plate thickness would be:

$$t = 4.17 \times 10^{-2} s \left(\frac{P}{\sigma_y}\right) \left(\frac{s}{W}\right) \theta \qquad (F.38)$$

w = allowable permanent set

P = design ice load (MPa)

s = frame spacing (mm)

σ_y = yield stress (MPa)

θ = function of plate aspect ratio (F.39)

$$\theta = \frac{\left(\sqrt{3 + \beta^2} - \beta\right)^2}{\left(1 + \frac{\zeta(\zeta - 2)}{3 - \zeta}\right)}$$

$$\zeta = \beta\left(\sqrt{3 + \beta^2} - \beta\right) \qquad (F.40)$$

θ is Tabulated in Table 1.

β	θ
0	3
.1	2.99
.2	2.96
.25	2.93
.33	2.86
.5	2.71
1	2

Noting the limited range of θ, a simpler and still accurate formula could be:

$$t = 0.125\, s \, \frac{p}{\sigma_y} \left(\frac{s}{W}\right) \qquad (F.41)$$

$$0.03 < \frac{W}{s} < 0.2$$

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